BIONOMIC INVESTIGATION OF THE MALAYSIAN LARGE SCALE FISHING SECTOR: A CASE STUDY OF KEDAH/PERLIS

by

MICHAEL D. NAHAN

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STATEMENT

This thesis describes my own original work.

Michael D. Nahan

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ABSTRACT

This thesis examines empirically the argument that the large scale fishing industry in the Malaysian states of Kedah/ Perlis is economically and biologically overfished. For this purpose, considerable data on catch and effort, costs, earnings, investment and personnel bibliography were collected from primary sources.

The analysis of the data and findings of this research are set out systematically in the chapters which follow. It is therefore the intention here to merely give a general view of the main findings of interest.

(i) In the purse seine fleet (which is in an advanced state of decline), although the fish stocks exploited are not in every case over-fished, they have become less available.

(ii) The fish stocks exploited by the trawl fleet were, in the aggregate, harvested at their maximum sustainable yield (MSY) in 1978/79. Significant variation, however, exists among the exploited taxa. For example, 8 of the 12 taxa which account for over 60% of total trawl catch were harvested at or below their MSY while most of the demersal taxa, particularly the demersal predators, were harvested at rates well in excess of their maximum sustainable production levels.

(iii) Contrary to existing information the trawl fleets earned substantial resource rent throughout 1969-79. Trawler crews too earned notably higher incomes than selected comparable occupations.

(iv) The supra-normal profits earned by the trawl owners and crew are, however, non-sustainable in, at least, the fish trawl fleet.

(v) An open access fleet harvest 13 taxa to the point of extinction.

(vi) The maximum net present value of the potential resource rent from the fish trawl fleet is estimated at $18-39 million (1969 Ringgit) with a fleet of between 75-93 vessels. The 'optimal' fleet thus represents a 53-60% reduction in the size of the 1978/79 fleet.

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CHAPTER 1

ECONOMIC SETTING

1.1 Introduction

The economic inefficiency inherent in an open access fishery has been firmly established in theory and by a long series of empirical studies. Excessive quantities of capital and labour will enter a fishery. In the long run over-capacity will worsen as real prices increase and new technology is introduced. Biological depletion will usually occur unless fishing mortality is curtailed by measures that limit entry of vessels and/or raise costs of fishing.

Since the opportunity cost of fishermen are often relatively low, open access conditions increase the disparities between the incomes of fishermen and other communities. In actual fact, most fisheries also experience returns to labour and capital that are often below their opportunity costs. This is because of inherent instability of the biological determinants of the physical functions linking yield and effort and the typical response of producers which is biased towards entry over exit. In a welfare state, this income differential would need to be ameliorated by transfer payments from other sectors of the economy.

Most major fisheries in developed countries are managed by a system which is designed to control fishing mortality. The most common means is to regulate access through some form of restrictive licensing. Many other political and social objectives enter into the decision making process. The primary objective of fishery management should be the attainment of maxmimum economic efficiency subject perhaps to equity considerations. Nonetheless very few fisheries are managed with this objective.

Very few developing nations have a coherent fishery management program. The emphasis in such countries has generally been to expand the productive base of their fishery with little consideration for their efficiency in the long run. An argument often forwarded is that most fisheries in developing countries are exploited predominantly by small scale fishing units with rather low productive capabilities. Such fleets, the argument goes, are unlikely to seriously deplete the fishery resource. Moreover the surplus labour conditions existing in most developing nations substantially reduce the social cost of open access equilibrium. Under these conditions it is likely that such fisheries are not suitable for a limited entry program because the cost of acquiring data and instituting the necessary management framework would exceed benefits that accrue.

There are, however, large scale fishing sectors in developing nations with trawler and purse seine fleets where the social cost of biological and economic over-fishing is substantial. These fishing units are relatively capital intensive and have crews drawn from the non-fishing sectors. The fishing power of these units are quite high and can be more readily enhanced by improved technology. Unrestricted access in such fisheries will also have detrimental effects on the livelihood of the small scale sector through competition for the same resource.

Despite frequent indications that the large scale fishing fleets have severely depleted their fishing resources and have become over-capitalised, very few nations have attempted to rationalise their large scale fisheries. The most debilitating obstacle to implementing a rationalisation program has been the severe inadequacy of information and research on the physical and economic functions of yield and effort. In the absence of such information neither the necessity nor the appropriate means of controlling fishing mortality can be assessed accurately. Of course, the countries may not enjoy the political conditions or have the institutional facilities and human capital essential to such a program.

It has been commonly argued that the Malaysian large scale fishery has been biologically and economically over-exploited (see Chapter 2). This has led to demands for resource management. If indeed there is a case for resource management, the present economic boom in Malaysia provides very favourable conditions for instituting the initial stages of a fisheries management plan. This is because prevailing high wages, the availability of work in non-fisheries activities and the rate of return on investment will increase the opportunity cost of capital and labour. This will in turn, at least in the short run, mitigate pressure on entry and facilitate the transfer of excess factors of production to non-fishing activities. These circumstances apply particularly to the west coast of Peninsular Malaysia.

The large scale fishing sector mirrors the dualism in the Malaysian economy as a whole. The means of production are controlled and/or owned by Chinese with the Malays providing the bulk of the low skilled labour. For this reason, the fishing industry has been a major beneficiary of government restructuring programs. The primary aim of these programs has been to enhance the income of the poorer income groups, i.e. the Malays, and to redistribute the wealth more equally amongst the racial groups. Naturally, neither the programs nor their objectives can, vis-a-vis the large scale fishing sector, be met if the potential rent has been completely dissipated through excessive entry. Furthermore, an assessment of the sustainable rent of these fisheries is fundamental to any redistribution decisions.

The aim of this thesis is therefore to re-examine the claims of biological and economic over-fishing in the Malaysian large scale fishery. For this purpose accurate primary time-series cross-sectional data of adequate length on the catch, effort, cost and earnings of a sample of trawlers and purse seine vessels at the study site had to be collected. Such data are not currently available but are essential to test the hypotheses on the subject. They are also required for a study of 1) the relationship between fishing and sustainable catch through estimations of the surplus production functions; and 2) the productivity of the trawl fleets and their income generating performances. From these biological and economic considerations an attempt is made to disprove the hypothesis of economic over-fishing of the trawl resources, to estimate the fleet size for the maximum economic yield, and to suggest the most feasible method of management.

The layout of this thesis is straightforward. This chapter briefly puts the Malaysian large scale fishing industry in some perspective in the wider context of the Malaysian population and macroeconomy. It becomes evident here that Malaysia is financially and institutionally capable of national inter-temporal management of its renewable fishery resources. Chapter 2 focuses on the large scale fishing sector in Malaysia. It considers in some detail the growth of the industry and the simplistic responses by the government to its complex problems which have left the industry in the sort of mess familiar to economists. Moreover, in appreciating the history of the large scale fishing sector, we gain instructive insight into feasible management alternatives for the industry. Chapter 3 deals specifically with the subject of this research - the Kedah/Perlis trawl industry. Much of Chapter 3 is devoted to all the essential aspects of the collection and use of data on the industry. Methods used to obtain information in the field, to check their accuracy and to decide on their worth or importance are discussed. Attendant problems are also dealt with.

Chapter 4 is concerned with the analytical and empirical framework of the thesis. The chapter first discusses population models with particular emphasis given to surplus production models. This discussion is later extended to deal with the application of these population models to tropical multi-species fisheries. A bionomic fishery model is introduced as an analytical tool to examine the effects of open access to a multi-species fishery and to identify the means of rectifying the attendant inefficiencies. The chapter finally presents a modified version of the NORSIM II simulation program for computing the potential economic rent of alternative fish trawl fleets.

The technical requirements necessary for estimating the surplus production models are ascertained in Chapter 5 and Chapter 6 presents the results of the surplus production functions for each species class.

The last two chapters concentrate on the twin problems of whether the Kedah/Perlis trawl industry is in fact over-exploited as is commonly accepted to be the case, and of estimating the optimal fleet size in steady-state conditions. The first task is approached in two ways - by looking at past trends in the rates of returns to crews and vessel owners and by simulation runs. Finally, it is attempted to make recommendations for the improvement of the existing management of the Kedah/Perlis trawl fishery.

1.2 Malaysia : Geographic Setting and Population

Malaysia is a small Southeast Asian country with a total land area of 127,370 square miles. Her population was about 13.25 million in 1979, having grown by 2.3% per annum since 1970. During the 1950s and early 1960s, Malaysia had one of the highest average population growth rates in the world at 3% per annum. The effect of this high growth is now illustrated in the rapid expansion of the 4.788 million strong labour force which grew at an average annual rate of 3.5% between 1976-78. The high proportion of young people in the population (42% of the total population was under 15 years of age) [BNM, 1979, p.110] and the increasing proportion of women participating in the market economy, will ensure the continuation of this high rate of growth in the labour force for the next few decades [Malaysia, 1979, p.65].

By Asian standards Malaysia is a sparsely populated country endowed with large tracts of unalienated agricultural land. In 1979, the population density was only 38.1 persons per square mile, as compared to that of 148.9 in the Philippines, 81.4 in Thailand and 71.9 in Indonesia [ADB, 1979, p.1]. Peninsular Malaysia, with 85% of the total population, had a population density of 78.9 persons per square mile and 422 persons per square mile in the more densely populated west coast states. The estimated total land area suitable for agricultural use in 1975 was 53,175 square miles of which 50% was unalienated [Malaysia, 1979,p.151]. This vast potential of unused agricultural land, not only holds promise for future expansion of total agricultural output, but also for the resettlement of surplus labour.

Except for the city-state of Singapore, Malaysia is, in spite of its sparse population, the most urbanised ASEAN country. In 1979, 35% of the nation's inhabitants lived in towns with populations of 10,000 or more. As discernible from the density of population, the west coast states, especially Penang, Perak and Selangor host the bulk of the urban population, approximately 54% of which were Chinese, 33% Malay and the remainder Indians and others [BNM, 1979, p.110].

1.3 Economy

Growth Rate and Standard of Living

In the last few decades, Malaysia has achieved a very respectable rate of growth and the second highest standard of living in South and Southeast Asia. Over the 1965-78 period, the real Gross Domestic Product (GDP) grew at an average annual rate of 8%. The consistently higher growth rate of GDP relative to the population resulted in the real GDP per capita (1970 dollars) increasing from US$271.81 in 1965 to US$484.32 in 1978. As shown in Table 1.1 this is the second highest GDP per capita in South and Southeast Asia and it is roughly equivalent to the GDP per capita of rapidly developing countries of East Asia. Malaysia's affluence can also be seen by its relatively high per capita private consumption and fixed capital formation, both of which are second only to Singapore in the region.

TABLE 1.1 : VARIOUS KEY MACROECONOMIC INDICATORS OF THE STANDARD OF LIVING FOR ASEAN AND SELECTED SOUTH AND EAST ASIAN AND DEVELOPED COUNTRIES, 1978 (U.S. DOLLARS)

	G.D.P. per capita	Private Consump. per capita	Fixed Cap. Form. per capita	Pop. (mill.)
ASEAN				
ASEAN Average	399.54	255.77	95.19	249.97
Singapore	3484.06	2153.76	1162.68	2.33
Malaysia	1258.21	684.42	314.40	12.91
Philippines	500.39	328.73	115.32	46.35
Thailand	484.32	317.10	131.06	45.10
Indonesia [1]	212.70	143.44	40.27	143.28
SOUTH ASIA				
Sri Langka	174.97	128.45	24.85	14.21
India [2]	142.47	101.72	27.11	610.08
EAST ASIA				
Taiwan	1465.27	729.14	373.17	16.86
South Korea	1244.87	760.27	389.46	37.02
DEVELOPED COUNTRIES				
U.S.A.	9643.02	6182.61	1715.30	218.50
Japan	9226.71	5304.00	2814.46	114.90
Australia	7598.83	4552.63	1743.07	14.25

Source : International Financial Statistics Yearbook 1979, I.M.F. Washington D.C.

[1] Figures are for 1977

[2] Figures are for 1976

Malaysia's relatively high standard of living is confirmed by the principal non-monetary indicators listed in Table 1.2 for the ASEAN countries and selected South Asian, East Asian and developed countries (see Lim,D.1973, p.17 for the use of non-monetary indicators). In all indicators, Peninsular Malaysia ranks amongst the most affluent in South and Southeast Asia, and is nearly comparable to the East Asian countries, although it is substantially behind the developed countries.

Foreign Trade

Malaysia's relative affluence and high growth rate has been largely achieved by pursuing an exported-oriented pattern of production. The private sector, with guidance from and, more recently, the direct participation of the public sector, has concentrated on the production and processing of those commodities in which it has a comparative advantage in international markets. The ideal climate, soil, suitable alienated land available at low cost and skilled human resources have led to the impressive development of the rubber and oil palm industries making Malaysia the world's largest producer and exporter of these products. In addition vast and easily accessible deposits of tin and stands of tropical hardwood, have enabled Malaysia to become the largest producer and exporter of both these commodities. Malaysia is also a net exporter of pepper, cocoa and coconut and natural resources such as copper, fishery products and most importantly, crude petroleum. In the last decade, a rapidly growing labour force, low wages and a high level of infrastructural development have allowed the rapid growth in exports of labour-intensive manufactured goods.

TABLE 1.2 : VARIOUS NON-MONETARY INDICATORS OF THE STANDARD OF LIVING IN THE ASEAN AND SELECTED SOUTH AND EAST ASIAN AND DEVELOPED COUNTRIES

		ASEAN					SOUTH ASIA		EAST ASIA		DEVELOPED COUNTRIES		
	Yr.	Sing.	P.M'sia [1]	Phil.	Thai.	Indo.	S.Lan.	Ind.	H.Kong [2]	S.Korea	U.S.A.	Japan	Aust.
1. Food Consumption													
a) calories/head/day	1974	2840	2580	1971	2382	2126	2019	1976	n.a.	2630	n.a.	2835	3310
b) protein/head/day in grammes	1974	756	565	501	500	438	426	480	n.a.	757	n.a.	859	986
2. Medical Facilities													
a) pop./physician	1976	1341	4873[3]	3154	8374	16390	4007	3961	1444	1999	617	845	721
b) pop./hosp. bed	1976	265	428	639	808	1625	334	1465	236	1406	155	95	81
3. Education Level % pop. of both sexes													
a) completed primary school	1970	22.9	28.5	55.9	5.5	22.6	47.1	5	29.2	27.5	93 [4]	69.8[4]	99.1
b) entered secondary school	1970	20.9	14.8	23.7	5.5	5.6	11.7	5	29.2	27.5	73 [4]	69.8[4]	38.5
c) entered tertiary institutions	1970	2	5.5	9.6	1.1	0.5	2.3	1.1	19.3	5.6	22.3[4]	21.5[4]	5.5
5. Communica. Facil.													
a) annual consump. of newsprint/head (kg.)	1977	12.5	3.9	1.7	1.4	0.4	0.1	0.2	14.6	5.4	41.6	20.3	38.3
b) radio receiver licences/1000 pop.	1976	156	118	43	131 [5]	37	58	24	527	139	1882	530	770
c) tel./100 pop.	1977	17.1	3	1.3	0.8	0.3	0.5[5]	0.3	25.6[6]	5.4	74.4	42.2	40.4
6. Transport. Facil.													
a) passenger cars/ 10,000 pop.	1977	61.6	40	8.6	6.7	3.3	6.9	1.3	28.8	3.45	502.7	174	394.7
b) commercial vehicles/ 10,000 pop.		24.8	13.2	6.4	5.7	2.3	3.6	1.1	11.6	4	120.6	101.5	94.5
c) steel consump./pop. in tons	1977	5620	50	31	31	8	2	16	262	186	618	512	365
7. Energy Facil.													
a) annual consump. of coal equiv./head in tons	1976	2262	578	329	308	218	106	218	1313	1020	11554	3679	6657
b) installed electrical generating capacity/ 10,000 pop. (kwh)	1977	606.6	107.9	79.95	64	11.59	30.13	40	658.2	173.9	2656.8	1074.5	1460.8

Source : U.N. Statistical Yearbook for 1978 (New York,1979).
[1] Data refers to Peninsular Malaysia; data on East Malaysia is not available.
[2] Data on Taiwan not available and data on Hong Kong is presented as a substitute.
[3] Economic Report 1979/1980, Ministry of Finance, Kuala Lumpur, Malaysia.
[4] Data for 1970.
[5] Data for 1975.
[6] Data for 1976.

The openness of Malaysia's economy is shown clearly in Table 1.3. In the 1976-78 period, export receipts constituted about 48.8% of GDP, an increase from 45.7% during 1961-65, while imports accounted for a further 37.1% of GDP. A further indication of the openness of Malaysia's economy is that custom duties from exports and imports, including surtax, represented just under 30% of total federal government revenue and over 70% of total indirect taxes [BNM, 1979, p.63]. In terms of employment, the agriculture, forestry, mining and manufacturing sectors which accounted for 97.7% of total exports, provided 59% of the total employment (see Table 1.4).

Malaysia has had a comfortable balance of trade surplus since 1965. The surplus increased substantially in 1976, largely as a result of the rapid growth in net petroleum exports. The average balance of trade for 1976-78 was $3,709.0 million up from $877.6 [1] million for the 1966-70 period (Table 1.3).

Composition of Gross Domestic Product

Since 1965, there has been a marked shift in the contribution of the various sectors to GDP as illustrated in Table 1.4. The primary sector which accounted for 76.2% of total export earnings in 1978, decreased in absolute share of domestic output from 40.5% in 1965 to 30% in 1978. In the same period, the secondary sector increased from 14.5% to 23% of GDP mainly because of the consistently high growth rate of the manufacturing sector. The tertiary sector, which

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[1] Unless otherwise stated, all monetary values are given in Malaysian Ringgit.

TABLE 1.3 : MALAYSIAN EXPORTS AND IMPORTS IN RELATION TO GROSS DOMESTIC PRODUCT

	1966-70	1971-75	1976-78
Gross Domestic Product			
at Mkt. Prices (mill.$)	51486	87864	93197
Exports (mill.$)	21910	36670	45496
Imports (mill.$)	18185	33235	34577
Balance of Trade Av.	877.6	817.6	3709
Exports (% GDP)	42.5	41.7	48.8
Imports (% GDP)	35.3	37.8	37.1

Source: Bank Negara Malaysia, Quarterly Economic Bulletin Sept., 1979, p.63

TABLE 1.4 : GROSS DOMESTIC PRODUCT, EMPLOYMENT AND EXPORT EARNINGS BY SECTORAL SHARES

	% share of GDP [1]		% share of tot. employ.		% share of tot. exports	
	1965[2]	1978	1965[3]	1978	1965	1978
Primary	40.5	30	54.5	45.9	84.5	76.2
Agriculture, forestry & fish.	31.5	25	52	43.9	54.5	50.6
Mining and quarrying	9	5	2.5	2	30	25.6
Secondary	14.5	23	12.5	17.5	12.2	21.5
Manufacturing	10.4	19	9	13.1	12.2	21.5
Construction	4.1	4	3.5	4.4	-	-
Tertiary	45	47	33	36.6	3.3	2.6
Total	100	100	100	100	100	100

Source : Bank Negara Malaysia, Quarterly Economic Bulletin, Sept., 1979, p.56

[1] GDP at factor cost.

[2] Second Malaysia Plan 1971-75, p.201..

[3] Data for Peninsular Malaysia only.

includes the public sector, service and the financial and trade industries, remained the dominant sector, indicating the importance of commercial activities in a trade orientated economy.

Primary Sector

The agricultural sector, which includes forestry and fisheries, is the most important sector with respect to share of total export (50.6%) and employment (43.9%) and is second only to the entire tertiary sector with respect to share of GDP (25%) (Table 1.4).

The natural rubber industry still dominates the primary sector with 29.8% of the sector's value added, 32% of the total employed labour force and 21% of total gross export earnings (Table 1.5). Oil palm grew from an insignificant crop to a major export commodity in the fifteen years from 1965-78 largely at the expense of natural rubber. The oil palm industry in 1978 produced 12.0% of exports, 4.0% of GDP and employed 8.0% of total employed (Table 1.5).

Rice or paddy ranks as the second agricultural crop in terms of total employment and cultivated area, and ranks third with regard to contribution to value added (Table 1.5). Padi cultivation takes place only on smallholdings of which 55% are less than three acres; the declared minimum economic size holding for an average full-time paddy farming household. Malaysia's rice harvest in 1979 is expected to reach 1,460,000 tons, 86.7% of which will be produced in Peninsular Malaysia. Rice production has increased at an average annual rate of 8.4% since 1965, pushing paddy production up to 85% of total domestic needs. The increase in rice production was brought about by the expansion of irrigation and drainage facilities and the introduction

TABLE 1.5 : VALUE ADDED, CULTIVATED AREA, EMPLOYMENT AND EXPORTS IN THE AGRICULTURAL, FORESTRY AND FISHING SECTOR (1970 PRODUCER'S PRICE)

	% of value added 1975	% of total cul. area 1975	% of total employed[1] 1975	% of total gross exp. 1978
Agriculture	75	100	91.5	49.9
Rubber	29.8	55	32	21.1
Oil Palm	16.7	19	6	12
Rice	9	13	16	-1.4 [2]
Coconut	2.6	8	4	0.5 [3]
Others	16.9	5	13.5	0.7
Forestry [4]	16.5	-	4	14.9
Fishery [5]	8.5	-	4.5	1.4
Agriculture, forestry & fishery	100	100	100	50.6

Source : Quarterly Economic Bulletin, Sept., 1979, vol.12, no.3, p.60

[1] Malaysia : Economic Performance and Long Term Issues, World Bank, 1978, Vol. 2, Chap. 10, p.A-17.

[2] Malaysia is a net importer of rice and rice bran. The figure given is net import of rice as a % of total gross exports.

[3] Coconut oil and copra included.

[4] Sawn logs and sawn timber included.

[5] Annual Fisheries Statistics,1979, Kuala Lumpur.

of high yielding varieties. Two large World Bank funded irrigation schemes, the Muda in the states of Kedah and Perlis and the Kemubu in Kelantan, became operational in the early 1970s. These schemes serve about 81% of total paddy acreage under double cropping in Malaysia [Ministry of Finance, 1979, p.109-110].

Kedah and Perlis form the rice bowl of Malaysia with 30% of total paddy land and produce 50% of total paddy output. The Muda irrigation scheme, has not only increased the income levels for all types of paddy workers, but has also expanded the demand for labour through increased double cropping. Although the impact of the scheme upon these states which have the largest agricultural sector (49% of GDP and 45% of their total employed labour force is employed in paddy production) has been beneficial, Kedah/Perlis remain two of the poorest areas in the federation [Malaysia, 1979, p.77 and Economic Consultants, 1978, p.B-2].

The timber industry is the second largest export earner in the agricultural sector and accounts for 16.5% of value added but only 4% of the sector's employed labour force (Table 1.5). The disproportionately low percentage of persons employed relative to share of value added and exports is explained by the high proportion of sawn or unprocessed logs exported.

Total timber production has reached a period of stagnation and insipid decline. At present harvest rates, total reserves in Peninsular Malaysia will last about 10 more years and for approximately 24 years in East Malaysia. A replanting rate at less than 2% of the present annual harvest rate in Peninsular Malaysia (and an even lower rate in East Malaysia) coupled with the substantial time required for tropical hardwood species to reach veneer size (between 50-150 years) mean that forest resources are not replenished but are exploited to the point of exhaustion. This is an illustrative instance of short sighted exploitation which is perhaps privately but not socially rational.

The fishing industry, though small compared to rubber and oil palm, is important as a source of food, exports, value added and employment (Table 1.5).

Fish products constitute 57% of the nation's total protein supply and 65% of annual protein consumed. The per capita consumption is about 22.2 kilograms per year; second to the Philippines in South and Southeast Asia. The high consumption of fish products is due in part to the fact that it is a traditional and acceptable source of food and protein for all the groups in Malaysia's multi-ethnic and multi-religious society. The large range in qualities and prices of fish products enable even the poorest segment of the population to purchase them. Total fish production in 1978 was estimated at 684,010 metric tons, of which 83% was produced in Peninsular Malaysia. The average annual growth rate of fish production was 14% from 1965-78; the second highest after oil palm in the agricultural sector [Annual Fisheries Statistics,1979].

Malaysia was a net exporter of fish products in 1978; $244.18 million worth of fish products were exported, representing about 1.4% of total export earnings. Japan was the largest purchaser (24%), followed by Singapore (19%) and Great Britain (16%). In the same year, $126.18 million worth of fish products were imported, 57% of which came from Thailand and 25% from Japan. The exports to Japan and Great Britain were largely semi-processed luxury items such as prawns, mussels, and lobsters. The local processing of these export items and the high degree of handling and preservation required in the local fresh fish market account for the relatively high share of value added. The imports from Thailand and exports to Singapore are composed primarily of first, second and third quality fish and fish products [Annual Fisheries Statistics, 1979].

In 1975 about 4.5% of the employed agricultural labour force was directly employed in fishing. This under-represents the true labour force of the fishing industry, because it excludes the labour-intensive support and associated activities such as processing, transport, and ice making. The latest estimate in 1970 reveals that about 3.76% of the economically active population of Malaysia was employed in the fishing industry, a figure which rates second after the Philippines in South and Southeast Asia [calculated from statistics given in Malaysia, 1976].

Mining Sector

Tin, along with natural rubber has been the cornerstone of the Malaysian economy, since the early colonial times, but in the last fifteen years it has steadily decreased in relative importance. Tin exports decreased from 23% of total export earnings in 1965 to 12% in 1978. This decline was due to the stagnation of tin production brought about by the absence of new reserves being brought into production and the depletion of existing mines [BNM 1979, p.60].

Output of crude petroleum rose substantially from 46,800 metric tons in 1965 to 10,556.1 million metric tons in 1978. This large increase in oil production resulted from the extensive and successful offshore exploration brought about by the sharp rise in petroleum price in 1973. The new oil fields which were discovered off the east coast and Sarawak, came on stream in 1976 and pushed crude production up to 13% of gross export earnings and, more importantly, made Malaysia a net energy exporter with a surplus of $873 million on total energy trade account. Large natural gas fields have been discovered in conjunction with these new oil fields [Ministry of Finance, 1979, p.123].

Secondary Sector

Apart from petroleum, the manufacturing sector has been the main source of growth in the Malaysian economy since 1965. The value added in the manufacturing sector has grown at an average annual rate of 11.25% between 1965-78, higher than any other sector and significantly above growth rate of GDP in this period [BNM,1979,p.56].

The processing of estate-type agricultural products and import substitution of consumer goods (such as motor vehicles, manufacturing of food products and paper products) in the 1960s gave way to export-orientated, labour or natural resource intensive industries such as textiles, rubber products, palm oil refining and electronics. This was the result of the government's initiative in the construction of infrastructural facilities including industrial estates and free trade zones, and the institution of a variety of economic incentives such as tax holidays, tariff protection and fiscal support.

The most important and desired result of the structural transformation in the manufacturing sector is the expansion in the relative share of total employment. The manufacturing sector's share of total employment which increased by 4.1 percentage points between

1965-78, and between 1970-78, provided 26% of all new jobs created (Table 1.4).

Tertiary Sector

The services sector grew at about the same rate as the economy as a whole over the 1965-79 period. Its relative shares of both GDP and employed labour force have increased slightly.

1.4 Characteristic Problems

Although Malaysia has achieved a relatively high level of affluence in the last fifteen years there are two characteristic problems which compel the continuous structural adjustments. They are: 1. high unemployment, under-employment and low income mainly amongst new entrants to the labour force and in the basic rural industries; and 2. the concentration, on the one hand, of wealth and skills with the Chinese and, on the other hand, of political power and control with the Malays.

Unemployment and Under-employment

The unemployment rate in Malaysia at 6.2% of the nation's labour force in 1978 is low by world standards. But in the absence of any type of welfare program, which mitigates the effects of unemployment the unemployment rate can be considered a serious social problem.

The rapid growth and structural change that have transpired in the economy since 1970 successfully reduced unemployment by 1.2% but the pattern of population growth exerts persistent pressure on the economy to absorb future entry into the labour force. Unemployment is presently most prevalent in the younger age groups, which generally possess few skills, little work experience and a low level of education. The 15-24 year age group formed 65% of the total unemployed in 1978 and only 35% of the total labour force. With this age group growing at 35% per annum, the economy must continue its rapid structural change towards more labour-intensive manufacturing industries. Spatially, the rate of unemployment is highest in the urban areas, caused largely by the urban drift of youths in search of jobs and by the "bright lights" phenomenon [Malaysia 1976, pp.59-65].

The official statistics on under-employment in the agricultural and fisheries sectors remain quite high despite a decrease in recent years. In 1977, 17.7% of the agricultural labour force worked less than 20 hours per week with an additional 18.7% working between 23-34 hours [Malaysia, 1979, p.64]. There has been little research into the extent to which this illustrates a preference for a low rate of participation in the labour force. The frequent reports in the last few years of labour shortages in the rubber, oil palm and paddy industries indicate that in fact under-employment is at least regionally or seasonally, non-existent [Lim, 1981].

The incidence of poverty in Malaysia is quite high [2] and is

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[2] Poverty, as defined by the Malaysian Government, is when a family or an individual receives less than a specified income, i.e. the minimal subsistence income level determined by the consumers price index and a basket of goods representing the minimum quantity of absolute necessities. There are numerous weaknesses to this approach which lead to over-stating the absolute level of poverty. The most significant is under-accounting of non-market and non-monetary income.

largely concentrated in the rural areas. In 1973/74, 37.5% of all households in Peninsular Malaysia had average per capita monthly incomes below the official poverty line. The rate of poverty for rural households was 45.3% as compared to 19.7 % for urban households [Malaysia, 1976, p.72].

Correspondingly, the most rural peninsular states, Kedah/Perlis, Kelantan and Trengganu, had the lowest per capita GDP and average household incomes. Rural poverty, in turn is endemic in the smallholder rubber, paddy and fishing households in which 57.9%, 64.7% and 69.6% respectively of all households were poor [Malaysia, 1979, p.44].

1.5 Distribution of Income, Wealth and Economic Power

The most politically explosive and economically disruptive problem facing Malaysia is that the largest population group, the Malays, has the lowest average income and is concentrated in the least productive sectors, regions and occupations and accordingly have a disproportionately small share of the nation's wealth and economic power. The present imbalance in income and wealth is rooted in the development of a dualistic economic structure under the colonial government. The immigrant races, the Chinese and Indians, were induced to migrate to Malaya, initially for a limited term, in order to supply the labour for the rapidly developing rubber, tin and their supportive industries. The Indians, mostly Tamils, were brought over to work on the plantations and, on a smaller scale, to provide a middle level public service and professional class. The Chinese migrants came as labourers in the tin mines and construction industries, but with their typical proclivity towards commerce, soon dominated the local and regional commercial and service sectors. The migration of the Chinese and Indians slowed down drastically during and after the great depression. The result was that the proportion of Chinese residents born in Malaya increased from 30% in 1931 to 76% in 1957 and the proportion of Indians born in Malaya increased from 21% to 60%. The Malays, for various reasons, did not participate in the modern sectors, but remained in their traditional smallholding agricultural niche. As smallholding agriculture lagged behind the modern sectors in terms of productivity and trade, the relative position of the Malays deteriorated [see Lim, 1973, pp.69-71].

The relatively low economic position of the Malays is undoubted: while they made up 55.8% of all households in 1973/74 they were 79.5% of all poor households. The major reason was that 69.5% of all Malay households resided in rural areas and of these 82.5% were employed in smallholding rubber, paddy or fishery, the most depressed industries. In contrast, the Chinese composed 33.3% of all households and 58.7% of urban households but only 15.3% of poor households [Malaysia, 1976, pp.178-180]. Another dimension to their unequal economic position was that in 1978 Malay individuals and interests owned only 10.3% of corporate asset as compared to the 43.7% and the 46% owned by other Malaysians and foreign residents respectively [Malaysia, 1979, p.49].

1.6 A Directed Resolution : The New Economic Policy

Notwithstanding the overall political stability, the May 13 riots which were sparked off by the outcome of the 1969 nation-wide elections, led to a sharp transition in the political orientation of the leaders of the coalition and UMNO (the leading Malay party). Prior to this incident, the ruling coalition assumed that the existing distribution of political power among the Malays, their special constitutional rights and the domination of the economic sphere by the Chinese were accepted. The dissatisfaction with this arrangement expressed in the riots led to the broadening of the base of the coalition through the formation of the National Front and, most importantly, the development of the New Economic Policy (NEP). The NEP as originally contained in the Second Malaysia Plan 1971-75 (SMP), and the Outline Perspective Plan (OPP) which covers the twenty-year period from 1970 to 1990 have the twin broad objectives of restructuring society and the eradication of poverty. More specifically, the objectives of the NEP are:

1. the eradication of poverty in all areas irrespective of race, particularly amongst the poorest of the poor, that is, the paddy cultivators, fishermen and rubber smallholders; and,
2. to increase the employment of Malays in the mining, secondary and tertiary sectors and to raise the share of the Malays in the ownership of productive assets and wealth so that by 1990 their share of total equity capital will be at least 30% with the other Malaysians retaining their 40%.

1.7 Development Strategy of the NEP

In the implementation of the NEP "equal priority will be given to the twin objectives of growth and distribution, since measures to eradicate poverty and structuring society complement and reinforce each other ... (and) will be simultaneously affected". A trade oriented pattern of production simultaneously with rapid structural transformation of the economy and export base will continue to be the primary pattern of development.

In general terms, the principal means of redressing poverty adopted is to concentrate funds and programs in depressed regions and to facilitate the mobility of surplus labour from the depressed rural areas to land development schemes and the secondary sectors in the urban areas. The restructuring of society is to be ensured indirectly through quotas in the labour, education and capital markets and directly through the operation of public enterprise in general economic activity.

Public development expenditure under the SMP and Third Malaysia Plan (TMP) consequently emphasises economic and social restructuring through more active and direct government participation. The $9,821 million outlay for public sector expenditure during the SMP was more than double the sum allocated under the First Malaysia Plan 1965-70 (FMP) and the revised public sector expenditure of $32,075 million under the TMP was three times the sum allocated under the SMP.

Nearly 40% of total development expenditure under the TMP was intended to be directly or indirectly related to the amelioration of poverty. Agriculture and Rural Development were to receive the largest share of 23.6% of the total outlay. The programs designed to facilitate migration to more productive areas and sectors, i.e. the land development schemes and educational programs, were to receive the major portion of the poverty redress funds. Other in situ programs designed to improve the productivity and efficiency of the rural sector were to receive a large portion of the remaining poverty related expenditures. These funds would be channelled through parastatal bodies, such as FELDA, MARA, Bank Pertanian and Majuikan, whose objectives are to enhance the productivity and profitability of their respective rural industries while ensuring that the lowest income group receive an improved share. In the long run at least it was hoped that the majority of the parastatal bodies will be self-financing. To reduce the regional imbalance, over 20% of the total development expenditure were to be allocated to the most under-developed states of Kedah/Perlis, Kelantan, Trengganu and Malacca.

1.8 Conclusion

Malaysia is in the initial stages of rising from the status of 'Less Developed Country' (LDC) to that of 'Developed Country' (DC). Like other "emerging" nations, Malaysia retains a number of characteristics typical of LDCs, such as a rapidly growing population and labour force, a high percentage of the population dependent upon small scale agricultural and fishery operations of low productivity, inequitable distribution of income, wealth and political power, and major earnings of foreign exchange from exports of natural resources or commodities directly dependent on natural resources. These characteristics will ensure continued heavy emphasis on fulfilling as quickly as possible the growing aspirations and demands of the people or, in other words, achieving growth in the short term.

Malaysia is also beginning to display qualities of DCs, which enable it to enforce inter-temporal and/or inter-generation utilization of its natural resources and environment. Some of these qualities are an adequate stock of human and physical capital, a dynamic manufacturing sector increasingly capable of absorbing the natural growth in the labour force as well as "surplus" agricultural labour, sufficient internal and external supply of funds to carry out major structural changes in the economy and political and administrative stability.

The problems associated with inter-temporal allocation of resources are of particular significance to Malaysia in the major renewable resource-based industries, forestry and fisheries. The present rate of exploitation of these renewable resources has reportedly reached levels that will lead to serious depletion of the resources in the near future. The ramifications of resource extinction or even the more likely event of a progressively economically depressed industry (particularly in the fishing industry) extend to detrimental effects on exports, food supply and most importantly the impoverished rural sector.

The NEP and the several five-year plans which state the government's development objectives and programs respectively, have given only peripheral consideration to the problem of inter-temporal allocation of resources and management of its renewable national resources. On the contrary, the programs and institutions set up to achieve the twin objectives of redistribution and growth, have increased pressure on the rate of exploitation of these natural resources.

CHAPTER 2

LARGE SCALE FISHING IN PENINSULAR MALAYSIA

2.1 Introduction

A study of the growth of large scale fishing in Peninsular Malaysia reveals an array of problems familiar in other sectors of the Malaysian economy. More importantly, it shows how the responses of the government to these complex problems have often been too simplistic and, consequently, ineffective in the management of the fishery. For example, possible over-exploitation of the resource, and a perceived monopsony in the hands of Chinese 'towkays' indicate the need for regulation. Unfortunately, the data on which the precise causes, nature and extent of the problems identified were often dubious and at best inaccurate. Baseless assumptions meant false or misleading conclusions. Bad diagnosis led to ill-suited remedies. To sum it up, the regulation of the industry fell far short of effective management.

2.2 Dominance of the West Coast

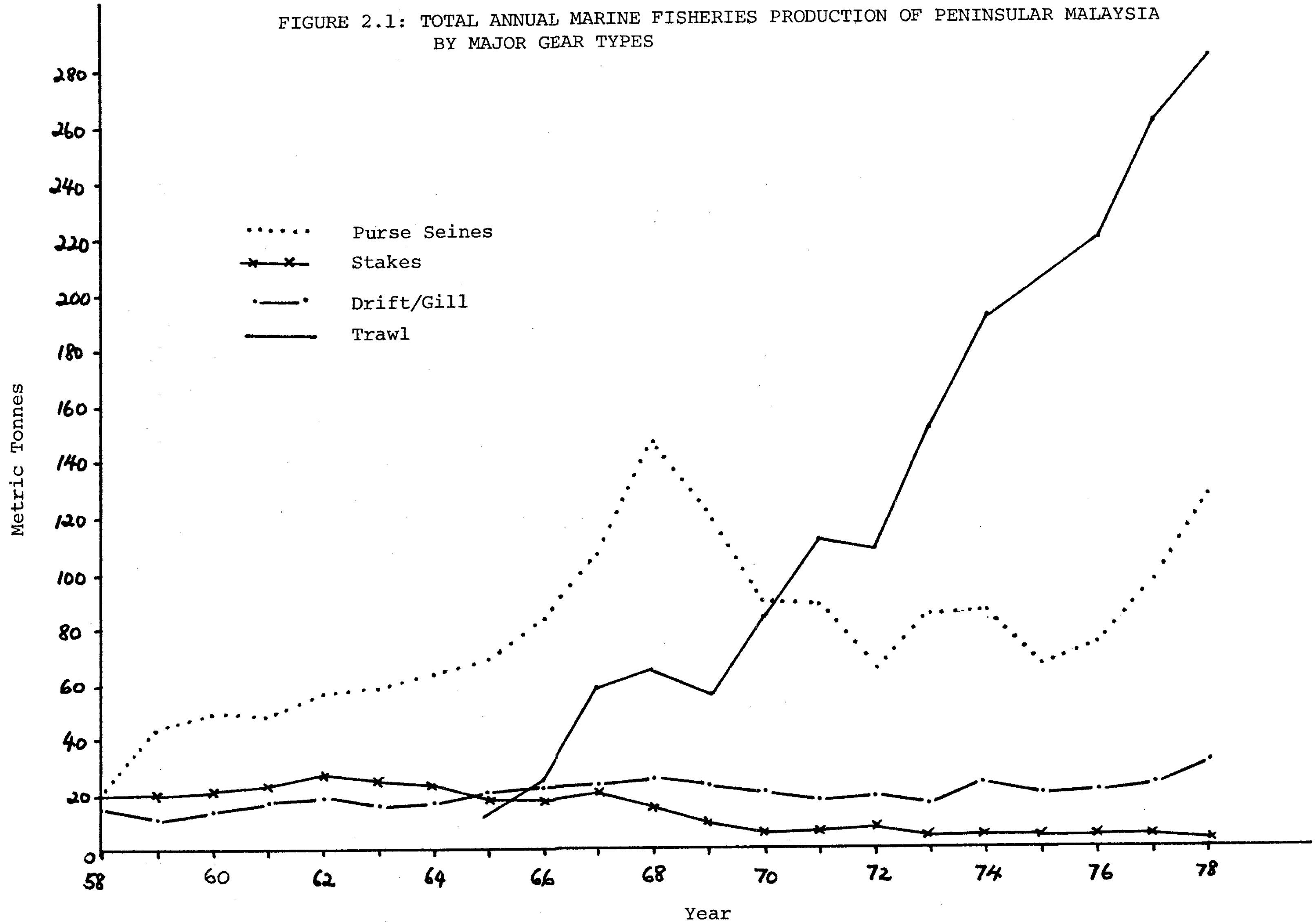
Since systematic records were first established in 1946, the marine fishing industry in Peninsular Malaysia has been concentrated on the west coast which produced on the average 73% of total estimated catch with only 65% of registered fishermen and 72% of licensed vessels. (Table 2.1 shows the relative share of licensed

TABLE 2.1 : DISTRIBUTION OF TOTAL CATCH, LICENSED VESSELS AND FISHERMEN IN PENINSULAR MALAYSIA BETWEEN THE EAST AND WEST COASTS (1978)

	East Coast		West Coast	
	No.	%	No.	%
1. Total Catch (m.t.)	154124	27	410774	73
2. Licensed Vessels (no.)	7797	28	19700	72
3. Fishermen (no.)	29603	35	54091	65

Source : Annual Fisheries Statistics, 1978

FIGURE 2.1: TOTAL ANNUAL MARINE FISHERIES PRODUCTION OF PENINSULAR MALAYSIA BY MAJOR GEAR TYPES



Source: Annual Fisheries Statistics, 1959 - 1979.

vessels, catch and fishermen operating on the two coasts.) The obvious inference is that the west coast is more productive in absolute terms and in terms of catch per man and catch per vessel. In recent years, however, the east coast is comparable with the west coast with respect to the ratio between catch and number of licensed vessels and the ratio between catch and registered fishermen.

The west coast fishing centres have achieved and maintained a predominant position in the Malaysian marine fishing industry primarily because of the larger concentration of more capital intensive or large scale fishing vessels and gear. The high absolute and relative profitability of fishing on the west coast, in conjunction with the larger pool of innovative fishermen and entrepreneurs with sufficient funds and skills to capitalise on this potential, have led to the introduction and wide scale adaptation of a continuous series of technological innovations on the west coast. On the east coast, these technological innovations have either been absent or adopted only in recent years, and even then on a smaller scale.

The fishing industry on the west coast has been more profitable than that of the east coast because there is greater accessibility to fishing grounds rich in various prolific and highly priced inshore species. These grounds and the fishing ports as well, are spatially and temporally closer to the wealthy urban markets which enjoy a technologically and economically more efficient marketing system.

2.3 Climate

Peninsular Malaysia has a humid equatorial climate with regional and seasonal differences determined by the dual monsoonal pattern of

South East Asia. The mean annual temperature for the coastal areas of the peninsula varies between 79°- 83°F with humidity between 82% - 86%. The east coast with its open coastline receives the effect of the north-east monsoon from November to March and has a median annual rainfall of 100 - 120 inches, 70 - 80 inches of which fall during the monsoonal months. The severe weather associated with the north-east monsoon is not as extreme as the weather in many other parts of Asia and the rest of the world, but three meter seas and gale force winds are frequent. The west coast is sheltered from the direct effect of both monsoonal systems. The central dividing mountain range provides protection from the north-east monsoon, while the Sumatran landmass attenuates the south-west monsoon system. Correspondingly, the median annual rainfall is lower than that on the east coast with a range of 70 - 120 inches and a higher degree of regional and annual variation. The average wind and sea conditions are more placid than those found on the east coast. The sea conditions do pick up somewhat from May to September during the south-west monsoon season although gale force winds and associated sea conditions are rare.

2.4 Coastal Topography

On the north-east coastline, where the monsoonal weather is most severe, the shoreline is composed of long sandy beaches with intermittent rocky patches. The offshore bottom is sandy becoming muddy past the ten fathom line, hosting numerous rocky or coral patches. The continental shelf in the South China Sea is very gradual and the 20 fathom line is beyond 15 nautical miles of shore.

From just north of Endau on the south-east coast around the tip of the southern peninsula and up to the Thai border, the shoreline is dominated by fertile mangrove swamps. In these relatively sheltered areas the littoral and sublittoral sea floor is very muddy with a few rocky and coral patches mostly around the various nearshore islands. The Straits of Malacca is very shallow with a depth of 15 fathoms in the southern reaches to a maximum depth of 40 fathoms in the north. A north-west current prevails up the strait throughout the year, except during June through August when the current abates, and sometimes reverses in the southern reaches. There are numerous heavily silted rivers along both coasts and in the river mouths or 'kuala' are located the major fishing centres. The east coast does not have any natural harbour besides the river mouths, whereas the nearshore islands off the west coast such as Pangkor, Penang, Langkawi and various other smaller islands, provide unhampered access and shelter during inclement weather.

2.5 Physical Accessibility

The necessity of navigating the shallow river mouths has led to the development of very shallow, broad beamed vessels, which are mainly constructed of a very heavy local wood, chengal. The monsoonal weather on the east coast limits the accessibility of fishing grounds by preventing the navigation of the shallow silting river mouths and by prohibiting the operation of these inherently unstable vessels at sea. Furthermore, disturbance during the monsoonal storms prevent the use of large palisade traps. On the west coast, more placid weather conditions and non-riverine shelters enable fishing and the use of large traps throughout the year.

2.6 Relative Productivity

The relative productivity of the east and west coast fishing grounds has not been accurately established although evidence from the trawl surveys carried out in the early 1970s indicate that in terms of total abundance and species diversity the east coast appeared to be richer. Notwithstanding this, it appears from trawl surveys and estimates of the Fisheries Division that the west coast has grounds which are more productive in prawns and "Kembong" (Rastrelliger spp.).

As a result of its high price, prawns are the key species for the majority of small scale gear and smaller trawlers, accounting for 20% of the total edible fish production in 1978 [Annual Fisheries Statistics, 1979]. On the other hand Kembong has been historically the foundation of the purse seine fleet in Pangkor and Kuala Kedah and is more recently the target species for most of the large trawlers on the west coast. It represented about 10% of the total 1978 edible fish production [Annual Fisheries Statistics, 1979].

The Fisheries Division's estimates for 1978 show an annual estimated catch per trawler of all prawn species of 234.5 pikuls on the west coast and only 72.5 pikuls on the east coast, the majority of which came from east Johore [Annual Fisheries Statistics, 1979]. This higher catch per unit effort is inspite of the heavier fishing intensity. The prawns are mainly caught close to the fertile swamps along the west and south east coasts.

The two coasts' share of the total Kembong harvest is considerably less disproportionate: 61% of the harvest comes from the west coast grounds.

2.7 Relative Marketing Efficiency

The market for fish products, particularly fresh fish, on the west coast is more extensive, enjoys a lower per unit marketing cost, and is more technically efficient than the east coast market. As already outlined, the rural east coast states are predominantly Malay, sparsely populated and have significantly lower average incomes than the west coast states which have the larger urban centres. Besides, transport and communication facilities, although being improved under the NEP programs, are inferior on the east coast. These characteristics limit the local east coast market, and at the same time increase considerably the absolute and relative marketing costs to the urban west coast and Singapore markets. The result is lower ex-vessel prices.

Another reason for the lower ex-vessel prices on the east coast is a possibly higher incidence of monopsonistic power. It has been consistently reported, since first examined in 1923 [Stead,1923] that the inter-state fresh fish marketing network exhibits characteristics and practices that allow collusive or monopsonistic power to be established especially in the smaller fishing centres. Although the same conditions have been reported on the west coast, the higher marketing costs and overheads together with the limited financial and entrepreneurial capacity of east coast Malay fishermen and fish dealers have given the Chinese, who have these resources, greater scope for monopsonistic control.

2.8 A Historical Outline of the Marine Fishing Industry with Special Reference to Large Scale Gear

The fishing industry on the west coast has passed through four stages [Yap,1977a] during which the industry has been dominated by a type of large scale gear. This growth process has led to the development of an extensive and efficient marketing system, a large pool of entrepreneurs and skilled fishermen, and, given local conditions and prices, a technically advanced subsector. The east coast did not achieve parallel development for reasons already mentioned. Consequently it became increasingly less competitive.

1900 - 1930

During the first stage which roughly covered the period 1900 - 1930 stationary entrapment gear or stakes were the dominant fishing technique both in number and share of total catch. Stakes were of a wide variety of sizes and costs, ranging from the large kelongs and jermal to the smaller ambai and gompang. The kelongs were concentrated in the more placid waters from Singapore to Selangor while the jermal and smaller stakes were used mainly off the northern states. Perak alone had an estimated 3420 traps in 1911 of which 3333 were ambai and 87 were jermal or kelongs [Yap,1977a,p.5].

The major reason for the proliferation of this gear type was that it produced a relatively high volume of output with a low labour input. The complete reliance on human and/or wind power in this period not only limited the absolute harvesting capacity of the mobile fishing units, but also necessitated large, valuable man-hour inputs. The minimal labour requirement, especially for the owners of the stakes, allowed for vertical integration with end use industries such as pig and duck raising, and fish and prawn processing. This overcame the problem of the disposition of large catches under conditions of a very limited fresh fish market and a rapid rate of deterioration of catch in the absence of preservation facilities.

The construction and management of these traps and the associated processing facilities required substantial capital and entrepreneurial skills: more than what artisan fishermen would have. The immigrant Chinese had access to both through affiliations with the rapidly developing mining and rubber industries. The financial requirements for the large traps were extremely high because of the initial costs as well as the risks of destruction by storms and, of course, the non-migration of fish into the stakes. In the course of field work, a couple of former jermal owners in Kedah, one of whom went bankrupt and the other became a millionaire, stated that the cost of a jermal with an average life expectancy of 6 months was, in the late 1930s, about $60,000.

By 1919, the rapid expansion in the use of stakes led to indications that the fish resources and the wood resources with which the stakes were built were over-exploited. In response the colonial government instituted the country's first renewable resource management programs to control the harvesting of resources and to tax the rent appropriated by the operators of the larger stakes [Fisheries Division, 1920]. The production of nibong wood was reduced by regulating the areas in and the rate at which logging was permitted. Reduced supply led to higher nibong prices which in turn led to a decrease in the average size of the large stake [Yap,1977a,p.11].

In the same year a mandatory vessel and gear licence scheme was introduced wherein the licence fee was set according to the size and type of gear employed. Annual fees of $24 and $12 were payable for large and small stakes respectively as compared to the charges of $1 and $4 for drift and other nets [Fisheries Division, 1920]. The higher licence fee for large stakes was a means of taxing the resource rent available to the owner of the traps. The stakes, it was believed, being stationary, prevented others from fishing in their areas and thus the owners enjoyed a quasi-property right which fetched an "excessive" rent. At the same time the use of the smaller stakes was prohibited. The <u>ambai</u>, the <u>gompang</u> and other small stakes were and are still operated close inshore with small mesh nets for prawns and anchovies. These functionally unselective units were said to be catching large quantities of undersized and immature species resulting in growth or recruitment over-fishing [Maxwell,1921]. The prohibition was relaxed after protests and in view of their wide-spread illegal use but these nets never recovered their previous prominence.

By the early 1930s, the restrictions imposed on the use of stakes resulted in escalating costs and the number of operating units stagnated although they remained a major gear throughout the 1940s, 1950s and early 1960s. In 1947, stakes were still the most commonly used type of fishing gear. An estimated 2467 units were in operation 675 of which were large stakes [Fisheries Division, 1948]. By 1964, the number of stakes had decreased to 1444 with 498 large scale units [Annual Fisheries Statistics, 1965]. Hereafter their number decreased rapidly in the face of competition from trawlers.

1930 - 1940

The combined effect of the restrictions on the use of traps, technological changes and regulations favourable to the purse seine contributed to the speedy growth of the latter. The purse seine which was introduced into Malaya by Chinese from Thailand in the late 1800s [Elliston, 1971, p.3] concentrated on the harvesting of Kembong off the coast of Kedah and near Pangkor Island. In the early years the limited local fish market and the lack of adequate refrigerated transport required the catch, which was often landed in bulk, to be salted. The first boost in the number of purse seine units followed the abolition of duty on salted fish in 1932 [Yap, 1977a, p.15]. Another influx of purse seines followed the increase in fresh fish prices that resulted from the refusal by the Chinese, and later the colonial government, to purchase or handle fish from Japanese vessels [Yap,1977a,p.16]. Hitherto the Japanese moroami and drift net fleets had supplied the bulk of fresh fish consumed in the urban areas of Malaya and Singapore.

Higher fresh fish prices and improved infrastructure on the west coast led to the development of ice facilities, faster and insulated transport vessels and a more time-efficient fleet organization which opened up the fresh fish markets of Penang and Singapore. As the fleet size and infrastructure grew, economies of scale decreased transportation costs and these in turn promoted further expansion of the purse seine fleet [see Elliston, 1971; Yap, 1977a].

The most important technological advancement of this period was the motorised transport vessel. The sailing junks from which the purse seine was operated were slow in conveying catches from the fishing grounds to port. This was not a serious problem if the catch was to be salted but was a major obstacle to gaining access to the fresh fish markets. Transport and handling were minimised through the mother-ship system similar to the contemporary Japanese drift net fleets and many fishing fleets of today. The mother-ship system not only produced higher prices by improving access to the fresh fish markets, but also introduced onboard refrigeration to the fishing industry.

Drift nets too came to be increasingly used when groups of Teo Chew Chinese fishermen migrated to Pulau Ketam off Selangor and Malacca respectively. The same drift nets had been used throughout the peninsula since before the first recorded description of the fishing industry. With the use of floats and weights the local nets were operated at various depths from small sailing vessels for a large range of demersal, mid-water and pelagic species. The Pulau Ketam fishermen using larger drift nets and sailing junks migrated seasonally from Pulau Ketam to various fishing grounds off Malaya and Sumatra.

The local fishermen including those from Pulau Ketam never increased the scale of their operations as much as the Japanese drift net fleets in Malayan waters. The Japanese used nets about 500 fathoms in length operated from large sailing vessels under a mother-ship system. The local Malayan drift nets were never longer than 60 - 120 fathoms and were operated from vessels of between 18 - 30 feet [Burdon and Parry, 1954,p.97].

1950 - 1965

The fishing industry was decimated during the Japanese occupation between 1942 and 1945. The large scale gear, the purse seine and the kelong or jermal suffered the most because large vessels and wood were needed for military purposes. The basic support and infrastructural facilities were also extensively damaged or destroyed. After the war, rehabilitation of the industry took about three years. However, sail cloth and marine diesel engines remained in short supply for another five years. By 1950, the purse seine fleet had reached its pre-war size.

The most important post-war technological development was the widespread motorization of individual purse seine fleets. Prior to the outbreak of hostilities only a few purse seine vessels had installed engines. After the war, the shortage of marine diesel engines led to the use of adapted lorry engines as substitutes. These engines proved to be cheaper and faster than the marine engines and resulted in the motorization of all purse seine vessels by 1947 [Fisheries Division, 1948]. The fishing power of purse seines was enhanced, fishing areas and fish stocks were enlarged. Fishing time was longer and more flexible. The result was increased rates of harvest, greater profits and eventually more purse seine units.

In the early 1940s, Malays in Kuala Kedah who had taken up purse seines in the 1930s, began to use lures or 'tuas' with purse seine nets. The lure which is a submerged cluster of palm fronds had been used by the Malays with other nets for centuries [Burdon and Parry,1954]. It is used to attract and concentrate pelagic and semi-pelagic fish species for effecting capture during daylight hours. Heretofore the purse seines were only operated on moonless nights when the fish schools could be spotted by the phosphorescence thrown up in their wake. The use of the purse seine with lures known as 'pukat jerut tuas', enabled the vessels not only to fish on any day of the month during daylight hours but also to harvest a wider spectrum of fish species. The lure purse seine rarely caught Kembong but concentrated on a wider range of Scad, Trevally and Sardine species. Its counterpart, the night purse seine or 'pukat jerut malam', although not confined to the capture of Kembong, caught the "Cincaru" or Hairtail Scad (Megalaspis cordyla) to a lesser extent. The wider range of harvested fish stock caused the purse seine to be used in areas traditionally not known to be rich in Kembong; for example Penang, Selangor, Mersing, and to a lesser extent, Trengganu and Kelantan. To attract fish at night, floating lights were used with the purse seine. This technique which began in Mersing in the early 1960s also increased the flexibility of the purse seine in areas not rich in Kembong [Elliston, 1971, pp.5-6].

Another significant technological change quickly adapted by the purse seine fleets in the late 1940s and early 1950s was the synthetic fibre net. Prior to this the nets were made of ramai or cotton fibre. These cotton nets were not very strong and were heavy as they tended to become water-logged. They also had to be dried after every use and treated with a solution once a month to prevent rotting. Repair and maintenance of natural fibre nets alone were responsible for over 40% of all lost fishing time. For the Malay lure units operating during the day the time lost was even greater since fishing days had to be used to dry the nets. Closer inshore operations only resulted in more damage to the nets from old fish stakes and other obstacles. Synthetic nets had none of these shortcomings: they were stronger, impervious to water and did not become water-logged. More importantly, lower repair and maintenance costs promoted their use and further reduced their cost [Heong, 1951, p.41].

In the late 1950s and early 1960s, with the introduction of synthetic nets, another type of purse seine net was developed to harvest the large schools of Anchovies or Ikan Bilis (Stolephorus spp.) which had been harvested with beach seines and stakes for many decades. But with these gears the fishermen had to wait for the Anchovies to come very close to shore. In 1960 a Malay boatowner and Chinese net dealers in Kuala Trengganu, assisted by the Fisheries Division, produced an effective purse seine net with a 1/8th inch mesh centre panel for harvesting off-shore schools of Anchovies. The anchovies are immediately cooked and dried thus avoiding the difficulties of marketing fresh fish on the east coast [Elliston, 1971,pp.5-6]. By 1963 the anchovy purse seine was in operation along both the east and west coasts.

The number of purse seine units in operation has never been large relative to the total number of licensed boats in Peninsular Malaysia. Although as shown in Table 2.2, the estimated number of purse seine units had increased gradually since the pre-war days with the largest increase occuring after 1963, the total purse seine fleet has always been less than 3% of total licensed fishing gear. The newer anchovy and lure purse seines were the most common varieties and over 50% of the purse seine catch in the recent years at least had come from the east coast.

The main reason for the relatively small number of purse seine units is their high costs and the high level of skills required to manage them. In 1965, the average capital cost of a purse seine unit was over $35,000 and the average running, repair and maintenance cost

TABLE 2.2 : ESTIMATED NUMBER OF PURSE SEINE VESSELS IN OPERATING IN PENINSULAR MALAYSIA

Year	Night Purse Seine		Total	Lure Purse Seine		Total	Anchovy Purse Seine		Total	Total P. M'sia	Tot.units licensed P.M'sia
	W.Coast	E.Coast		W.Coast	E.Coast		W.Coast	E.Coast			
Late 1930s [1]	50	-	50	-	-	-	-	-	-	50	n.a.
1950 [2]	58	-	58	20	-	20	-	-	-	78	11880 [3]
1955 [1]	76	9	85	21	10	31	-	-	-	106	17606
1960-63 [1]	76	-	76	21	35	56	-[4]	63	63	195	19742
1978 [5]	100	-	100	95	178	273	79	87	166	539	20315 [6]

[1] Elliston, "A Survey of the Economics of the West Malaysia Pukat Jerut (Purse Seine) Industry in 1966" (unpublished manuscript, University of Hull, 1971.

[2] Report of the Committee to Investigate the Fishing Industry, 1955, Division of Fisheries, Kuala Lumpur.

[3] Licensed gears in 1947.

[4] Supra, Elliston reported that the anchovy purse seine had been introduced to the west coast in 1963, but did not report the number of fishing units in operation.

[5] Annual Fisheries Statistics 1979, Fisheries Division, Kuala Lumpur.

[6] Estimates number of fishing gear in operation.

of about $38,000 [Elliston, 1971, p.33]. This compared with a $2,000 - $5,000 capital cost for the drift or gill and lift nets in 1971 [Yap, 1976, p.38]. A purse seine vessel had on the average a 24 man crew, and caught an average 288 tons per annum which were sold in fresh and salted fish markets throughout the peninsula from Thailand to Singapore [Annual Fisheries Statistics, 1966]. The organisational, management and marketing skills required to operate a purse seine were often well beyond the training and capabilities of fishermen.

It is not possible to obtain estimates of the total catch from the purse seine fisheries because the available statistics lump the purse seine catch with that from all other types of seine nets. If it is assumed that the purse seines account for the major portion of the catch from all seines, the total seine catch can be used as a proxy. Figure 2.1 shows the absolute and relative shares of total marine fishing production from the four major gear classifications in Peninsular Malaysia from 1958 - 1978. The seine net dominated the fishing industry til 1970 with at least 30% of total catch. The drift or gill nets produced about 20,000 tons throughout the period but their share of total catch decreased from 15% to 6%. The shares of the stakes as mentioned earlier decreased gradually in both absolute and relative terms.

The major technological advances adapted by the purse seine units in the early 1950s, the engines and synthetic fibre nets, soon spread to the smaller scale fishing units. By the early 1960s nearly all fishing nets used in the Peninsular were constructed of synthetic fibres. The benefits of these nets had greater positive impact on the small scale fishing units than any of the other technological and infrastructural developments of the period [Lawson,1975].

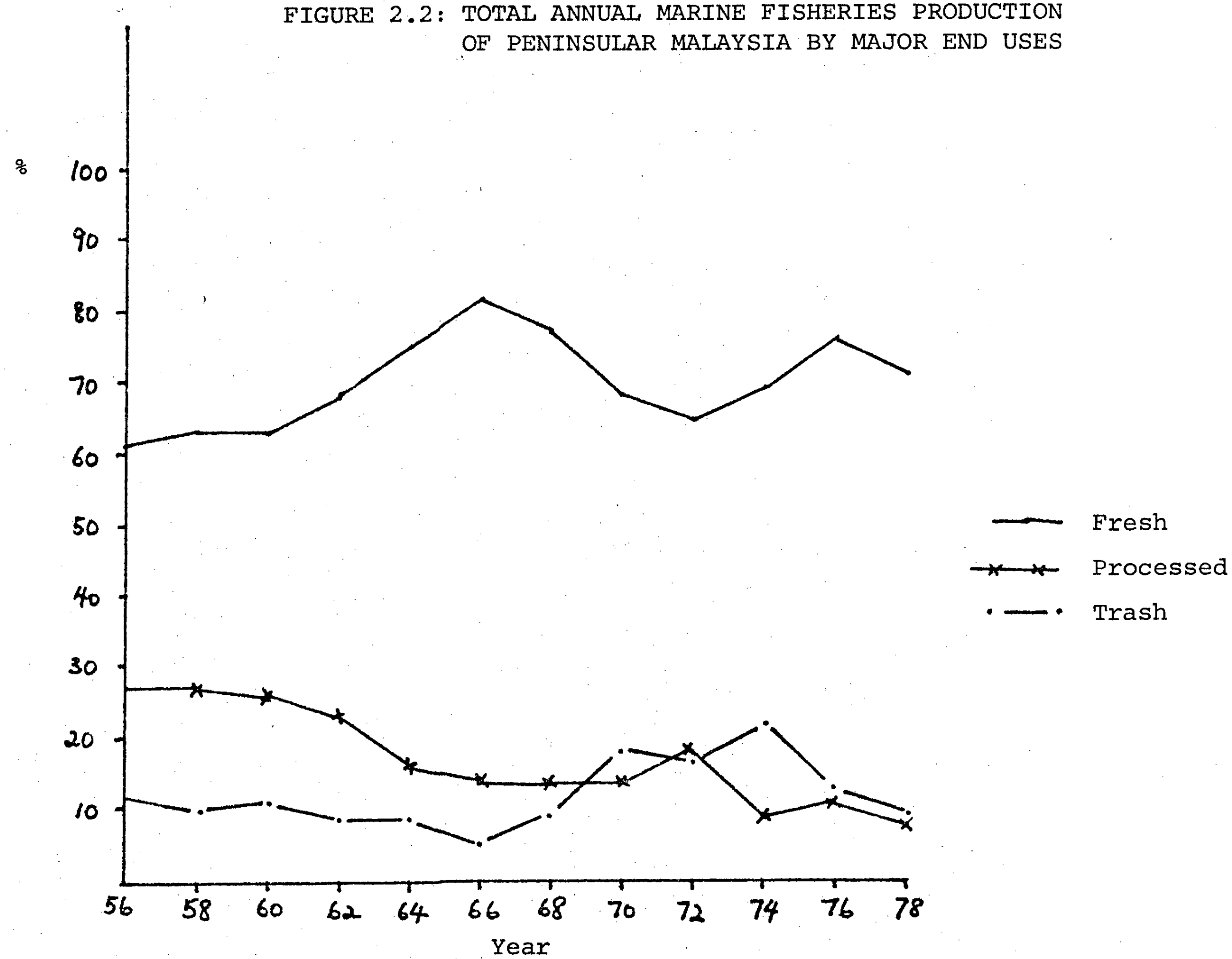
Mechanization was slower than the adaptation of the synthetic nets, but by 1978 over 80% of all licensed vessels had engines of which more than 65% were inboard [Annual Fisheries Statistics, 1979].

With the development of the purse seine and the economy as a whole, the fresh fish market gradually became a major outlet for marine fish in Peninsular Malaysia. In 1946, the Fisheries Division estimated that 35% of the total marine fish production was processed, 38% used as trash fish or manure and the rest consumed fresh. As shown in Figure 2.2, the share of total catch consumed fresh increased gradually til 1965 and stabilised thereafter at about 70%. The share of catch that was used for fish meal or manure decreased with the decline of the stakes but increased after 1965 with the rise of trawling.

1965 - the Present

The 1919 investigation of the fishing industry ironically recommended the establishment of trawl fishing as a replacement for the functionally unselective and destructive small stake. In response, the S.T.Tongkol, a 200 ton steam vessel, was brought to Malaya in 1926 to experiment with various types of trawl nets. The result of the experiments, with respect to the establishment of trawling on a large scale, were not encouraging. The total annual running cost was calculated to be $157,000 as compared to only $84,000 in sales receipts [Yap, 1977a, p.32]. Numerous other government sponsored attempts such as the S.T.Tongkol experiments in 1927 and 1928, and the Kembong and Marihenne tests with the two side trawlers in 1954 and 1956 respectively were made to introduce trawling. These research vessels were large ocean-going ships of over

FIGURE 2.2: TOTAL ANNUAL MARINE FISHERIES PRODUCTION OF PENINSULAR MALAYSIA BY MAJOR END USES



Source: Annual Fisheries Statistics, 1957 - 1979.

200 gross tons with power units of between 200 to 400 horsepower. A couple of private ventures are reported to have procured experienced personnel and large ships from abroad to test the commercial viability of trawling off the west coast in the early 1950s. The general conclusion of these private and public experiments was that the inshore waters off the west coast had very limited demersal stocks and a muddy bottom both of which were deemed unsuitable for commercial trawlers of the scale tested. The offshore areas were also found to contain insufficient fish resources to maintain a trawl fishery. But it had been recognised by Green [1927, p.24] that "in areas within (the) 10 fathom line small, locally built boats, manned and commanded by asiatics promised to revolutionize the inshore fishing of the peninsular." This was what happened when trawl gear from Thailand was introduced in the early 1960s.

Thailand has historically been the leading innovator in the region in new and improved fishing technology. The Chinese who began migrating to Malaysia through Thailand in the 1800s, brought first the large palisade traps and later the purse seine net. Many of the technological innovations that revolutionised the purse seine fleet in the 1950s, such as the use of lamps to attract and concentrate fish, the conversion of lorry engines as substitutes for costly marine engines and the method of using the engines to shoot the net, came from Thailand. In Kedah, which is close to the Thai border, and less frequently, on Pangkor Island off Perak, Thais were brought in as skilled labour to build traps, vessels and nets. Thailand was also a source of skilled and hard-working seamen. The most significant innovation introduced from Thailand was a trawl net which could be used profitably with existing local motorised vessels.

Thailand, like Malaysia had on numerous occasions experimented with large ocean-going trawl vessels in the earlier part of the century. The conclusion of their tests was the same as Malaysia's: that large trawlers were unprofitable and that a trawl net and associated propulsion system that could be fitted to existing local vessels at minimum costs were needed. In 1961, The Demersal Fish Investigation Unit was set up under the Thai Department of Fisheries with assistance in the form of fishery technicians and funding from the Federal Republic of Germany to fulfill this need. After only four weeks, a suitable otter board trawl net now known as the Thai trawl was designed. The net proved to be very successful with local wooden purse seine vessels of between 30 - 50 tons using converted lorry engines of 120 - 175 horsepower. The training of local fishermen was done simply by holding 2 to 3 day training courses in a large number of villages along the Gulf of Thailand, at which the construction and repair of trawl nets and the essential techniques of trawl fishing were demonstrated. Local fishing vessel owners grasped the techniques and the potential profitability of the trawl very quickly. By 1965, 60% - 70% of all purse seine vessels had converted to trawling and a large number of new vessels were added [Tiews, 1973, pp.4-5].

Thailand also pioneered the development of other types of trawl nets during the 1960s. Pair trawling, using two small 30 foot vessels and a fine mesh net was developed and became the major type of trawling unit in the Gulf by the late 1960s. The prawn net which is essentially a smaller, finer meshed version of the Thai trawl was disseminated from Thailand. During this time the trawl gear spread throughout the Gulf of Thailand, Cambodia, South Vietnam and across the Indian Ocean.

In 1963, only two years after commencement of the trawl research, a group of Thai trawlers introduced the gear and technique to fishermen in Kuala Kedah and Pangkor. The local purse seine owners and fish dealers, most of whom were Chinese, persuaded by the productivity and adaptability of the gear began to convert their purse seine vessels or to construct new ones for trawling. In 1964, the prawn trawl was introduced to the drift net fishermen in Pulau Ketam who converted their vessels to trawling and who in their yearly migration, introduced the prawn trawl throughout the peninsula.

Within twelve months of their introduction there was an estimated two hundred fish trawlers and seven hundred prawn trawlers operating throughout the peninsula [Annual Fisheries Statistics, 1967]. This influx of trawlers was opposed by operators of other types of gear. The non-trawler fisherman maintained that the unselective trawlers destroyed fish stock through recruitment over-fishing and in doing so also destroyed their gear and threatened their livelihood. The frequent violent clashes between trawler and non-trawler fishermen which followed led to a total ban on trawling by the federal government in early 1964.

The ban was lifted in early 1965 and trawling came under government control in response to the expansion of the trawl fleet that continued inspite of the ban, the resultant escalation in confrontations between trawl and non-trawl fishermen and the perceived need for a gear which could improve the productivity of the small scale fishermen. Before the ban was lifted, a pilot scheme was launched in October 1964 to devise methods for more effective control of the trawl fleet, so that this method of fishing could be expanded without detriment to the small scale fishermen.

Under the pilot scheme twenty fish trawlers based in Kuala Kedah and owned by a group of leading Chinese fish dealers and boatowners, were allowed to fish off Pulau Langkawi. The spatial and temporal application of fishing effort, as well as the racial composition of the crew were strictly regulated. These regulations were complied with by the participants. After two months the scheme was adjudged successful and a limited number of trawl licences was issued.

Trawl licences were and continued to be issued subject to stipulations governing the area in which the trawl could operate, the minimum mesh size, the ports open to trawlers and mandatory membership in a cooperative. The licences, the number and allocation of which are jointly decided by the Federal Ministry of Agriculture and Fisheries and the state governments with the Chief Ministers of the states having the final word, are restricted to permanent residents of the states.

To decrease the competition between trawlers and other gear, to induce the trawlers to exploit the perceived untapped demersal resources beyond the 12-mile limit, and to legalise the large number of small unlicensed vessels, the 1963 law which restricted trawlers to vessels of 50 tons and more was amended as follows. Licensed trawl vessels which are 100 gross tons and above and/or which have engines of 200 horsepower and above can trawl only in waters beyond 12 nautical miles from shore; while those of 25 gross tons but less than 100 gross tons, or with engines of 60 horsepower can fish only in waters beyond 3 nautical miles off shore. In addition, trawlers can only operate in waters off the state in which they were licensed and were restricted to the 49 major fishing centres in the peninsula. A trawler had to land its catch in the port where it is legally based.

A minimum mesh size for prawn and fish trawl nets was gazetted but was not enforced. Two types of trawl nets, the beam and the pair trawl, were banned because of their fine mesh which results in the excessive harvesting of immature fishes [Selvanathan,1979].

2.9 Fishery Cooperatives : Their Historical Development

Ever since the fishing industry was first examined by D.G.Stead [1923], the small scale fishermen have been unanimously identified as a particularly impoverished group. Their impoverished condition, it has been argued, is largely the result of monopsonistic power wielded by the market agents or 'towkays'. Under the towkay system, as practised in the fishing industry [see Elliston, 1967; Chaps.3 and 7], the fisherman, either as boatowner or crew, receives loans from a towkay and in return sells all his catch (or services in the case of the crew) to the towkay. The towkays through their control of funds and other factors are able, it is argued, to set the price for the fishermen at a level far below that which is perfectly competitive.

A committee of the Legislative Assembly was set up in 1955 to investigate the fishing industry and to recommend means to improve the income of the fishermen. After seven meetings with fishermen throughout the peninsula, the committee findings were similar to those of earlier investigations: the towkay system resulted in excessively low ex-vessel prices of fish. This not only accounted for the low incomes but also prevented the adoption of more productive fishing units and gear.

The committee recommended that the fishermen be encouraged to organise themselves into cooperatives or associations with trained advisory staff provided by the government. Loans to purchase more productive fishing gear should be given by the government to the members through the cooperatives. A government-run marketing scheme had been set up in Kelantan in early 1955, and it was recommended that the scheme be duplicated throughout the east coast. Unfortunately, the marketing scheme was dissolved a few years later when it proved ineffective.

The cooperative system was recommended because, "it is no part of our (the government's) aim to set up new capitalists or to finance those already in existence" [Legislative Committee, 1956]. It was also thought that until some form of governmental control of marketing was established, the cooperatives were a means of instigating group resistance to the "exploitation" suffered at the hands of the towkays.

In 1956 - 1957 fifty six new fishing cooperatives were set up along the east coast and given $1 million worth of loans. These loans were given by the federal government at 12% interest per annum with a 10% down payment and a 3-year repayment period.

The cooperative membership expanded quickly in the first few years or while the new loanable funds were available. When additional funds were stopped by the government because of poor repayment, membership in the cooperatives fell and these establishments became dormant by 1961. Of the $1 million in loans given out, $990,585 was still outstanding and $150,146.68 in interest still owing in 1962 [Yap, 1977b, p.3].

In 1961, a new series of seven cooperatives were set up on the west coast, the raison d'etre being the same as its predecessors which was the perceived need to inject capital and to guide self-help to overcome the monopsony powers of the towkays. The financial aid provided to the west coast cooperatives failed for reasons similar to that experienced with the earlier east coast scheme.

The cooperatives failed mainly because their establishment was not motivated by or reflected the desire of the fishermen to improve their lot in life through collective action but was imposed from above by political decree. The sole incentive to join had consequently been the promise of easy loans by the government. The funds and in general the cooperatives were reportedly dominated by the local elites for their own benefit and the fishermen showed interest only as long as funds were available. The cooperatives were a foreign institution not integrated into the local fishing society and were treated as such. The known reluctance of the government to enforce the repayment of loans and the absence of any pressure to repay encouraged disregard for the obligation [Gibbons, 1976, p.113].

The state of the fishing industry as ascertained by the committee, the ameliorative measures it recommended, and the choice of the instrument of the cooperative as the means to resolve the problem were all based on suppositions and not on objective empirical analysis. It was assumed that the fishermen, given the funds and countervailing power through the cooperatives, could and would break out of the vicious cycle of poverty imposed upon them by the towkay system. This presupposes that 1.the towkays have monopsony power, 2.the fishermen, most of whom are illiterate, and the government-supplied staff, most of whom were inexperienced, could carry out the function of the towkay and at the same time ensure a high ex-vessel price, 3.the resistance from the elites, the towkays and the conservative fishermen could be overcome and 4.the cooperative would be assimilated into the traditional social structure. Post mortems conducted on the cooperative scheme show that each of the four presuppositions was not completely warranted.

The terms under which the loans were given were too costly for the intended beneficiaries. The 10% down-payment forced the borrower to procure funds elsewhere or to sell accumulated assets. The 12% interest was too high and the 3-year repayment period too short for the fishermen. The inflexible repayment schedule only promoted delinquent repayment. The bulk of the loans from the towkays had been obtained for the purposes of running or variable expenses whereas the cooperatives only catered for fixed item capital funds. The need for short-term loans led to continued association and hence marketing with the towkays.

The hasty implementation of the schemes meant inexperienced, untrained and insufficient staff. The loans were consequently allocated improperly with respect to economic viability and the recipients inadequately screened.

In 1965 trawling rekindled interest in the cooperative movement. Trawling was identified as the technology through which the productivity and thus the income of the fishing sector could be improved. To ensure that the artisanal fishermen, particularly the Malays, actively and equitably participated in the incipient technological revolution, the government required that all trawlers be licensed through fishing cooperatives.

The regulations stipulated that trawl licences were to be issued and thus controlled by cooperatives. The owner of a trawler for which a licence was issued, could use the licence as long as he was a member in good standing with the cooperative that granted the licence. Pertinent regulations from which the objectives of the cooperatives can be gleaned provided that 1.fifty per cent of all trawler crews were to be Malay artisan fishermen, 2.eventually all landing and inputs were to be traded through the cooperatives 3.a monthly tax based on a percentage of net income and consumption of fuel and ice was to be collected, 4.the owners of trawlers were to furnish accurate monthly data on catch, effort and itemised costs and earnings, and 5.the vessels were to observe all other zoning and licensing regulations.

The government's decision to revitalise the fish cooperative system was taken in the belief that the suppositions underlying the previous schemes were still valid. The fact of the matter was that the cooperatives needed time and funds to become operative again. In this regard it was believed that the control over licences and the power to tax the lucrative trawlers would give the cooperatives the needed time and funds to develop their latent collective spirit and potential. It was implicitly assumed that the stipulated objectives of the trawl cooperatives would also be their actual operational objectives. Funds obtained by the cooperatives, it was also assumed, would be used to provide loans for the purchase and operation of trawlers or to invest in profitable local non-fishing ventures thereby making the cooperatives financially independent and solvent.

2.10 Growth of Trawlers

The high absolute and relative profitability of trawling, the ease with which existing purse seine gear could be converted to trawling, and the availability of loans from towkays and other sources created continuous additions to the number of trawlers. The estimated number of trawlers in Peninsular Malaysia increased at an average annual rate of 62% between 1965 and 1978 (see Table 2.3). The largest increase occured in the first five years during which the total estimated number of trawlers increased seven fold from 618 to 4049. The fastest growth took place on the west coast which by 1978 had over 82% of the estimated number of trawlers in operation. The west coast states of Perak, Selangor and Kedah/Perlis boasted the largest trawl fleets in 1978 with 1819, 1517,and 724 units respectively, representing 73% of all trawlers in operation [Annual Fisheries Statistics,1979].

Small prawn trawlers have always been the majority of trawlers in operation in Malaysian waters. They are mostly converted drift net vessels and other small scale motorised vessels. Figure 2.3 shows the tonnage distribution of licensed trawlers in Peninsular Malaysia in 1978. The smallest 0 - 9.9 gross ton trawlers made up over 40% of the trawl fleets on both coasts. The rest were the 10 - 19.9 gross ton and 25 - 49.9 gross ton vessels in about equal number. Two major trawler states, Kedah/Perlis and Perak, exhibit extremes in tonnage distribution. In Perak over 85% of licensed trawlers were under 20 gross tons whereas in Kedah/Perlis more than 50% of licensed trawlers were over 25 gross tons. On the west coast, trawlers less than 25 tons are mainly prawn trawlers and those over 25 tons are fish trawlers. The exception is Penang where government regulations require all trawlers to be more than 25 gross tons. These fish primarily for prawns. On the east coast, however, vessels of all tonnage, many of which operate only as part time trawlers, go for fish.

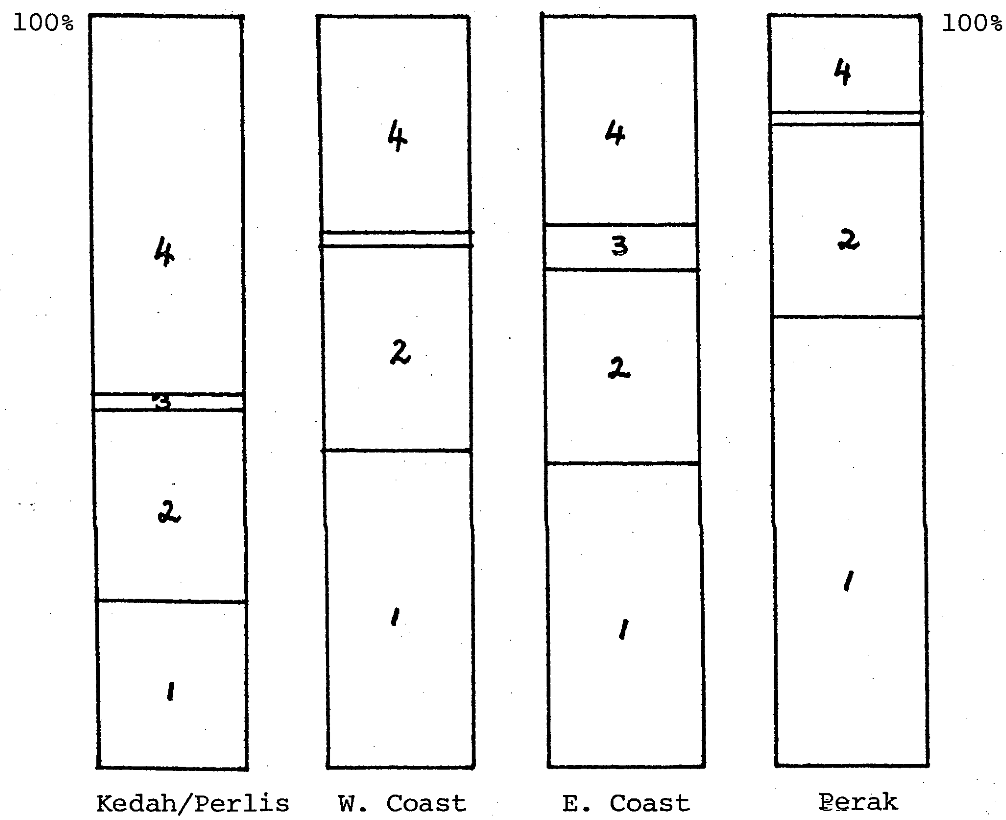
The licensing regulation was ineffectively enforced. Table 2.4 shows the estimated number of unlicensed trawlers operating off the

TABLE 2.3 : ESTIMATED NUMBER OF TRAWLERS OPERATING IN PENINSULAR MALAYSIA

Yr.	P.M'sia	E.Coast	W.Coast	W.Johore	Selangor	Perak	Penang	Perlis/ Kedah
1965	618	243	375	-	249	106	(60)	20
1966	915	398	517	-	292	155	41	29
1967	1290	230	1060	-	621	274	48	117
1968	1489	209	1280	27	553	457	89	154
1969	2701	712	1989	68	538	876	223	284
1970	4049	963	3086	102	800	1282	278	369
1971	4642	1120	3522	200	858	1711	330	464
1972	5328	1310	4018	232	808	2084	385	309
1973	4227	730	3497	261	688	1666	349	533
1974	4917	808	4109	285	1163	1786	319	556
1975	5632	910	4122	287	1173	1799	288	575
1976	5269	1059	4210	287	1263	1819	266	575
1977	5279	984	4295	286	1335	1770	237	667
1978	5528	929	4599	287	1517	1819	212	724
Av. Ann. Growth Rt	62%	22%	87%	97%	40%	125%	20%	271%

Source: Annual Fisheries Statistics, 1966 - 1979

FIGURE 2.3: DISTRIBUTION OF THE PENINSULAR MALAYSIAN PERAK AND KEDAH/PERLIS TRAWL FLEETS BY TONNAGE CLASS (1978)



1 - 0 to 99 tonnes
2 - 10 to 19.9 tonnes
3 - 20 to 24.9 tonnes
4 - 25+ tonnes

Source: Annual Fisheries Statistics, 1979.

TABLE 2.4 : ESTIMATED NUMBER OF ILLEGAL TRAWLERS OPERATING IN PENINSULAR MALAYSIA

Yr.	Illegal Trawler	Licensed Trawler	Tot.Oper. Trawler	New Trawl Lic. Iss.
1965	598	20	618	
1966	855	60	915	40
1967	1110	180	1290	120
1968	1161	328	1489	148
1969	1967	734	2701	406
1970	2700	1349	4049	615
1971	1156	3486	4642	2137
1972	1355	3973	5328	487
1973	159	4068	4227	159
1974	760	4157	4917	89
1975	867	4165	5032	8
1976	954	4315	5269	150
1977	994	4285	5279	-30*
1978	1024	4504	5528	219

* On the east coast, the number of licences renewed was decreased.

Source: Annual Fisheries Statistics, 1966-1979 peninsula between 1965 and 1978. Despite the considerable reduction in the number of unlicensed trawlers in 1971 and again in 1973, the population of these unlicensed vessels continued to increase.

Lenient enforcement of the trawl licensing regulation could be traced to the belief on the part of state fishery officers, politicians and judges that in the absence of accurate and comprehensive evidence indicating over-fishing a fisherman should be allowed to earn his living the best he knows how. Enforcement officers have on numerous occasions expressed "reluctance to take a man's rice bowl away when there may be enough rice for everyone" [Personal Communication]. Research attesting to both biological and economic over-fishing supplied by, inter alia, the fishery research division at Glugor as early as 1972 was known to ground level personnel to be sketchy and often inaccurate (see next section). The fishermen's counter-argument that trawling was still very profitable was sufficient to arouse sympathy amongst the enforcement officers. Shortage of patrol vessels and alleged corruption among the officers too encouraged illegal trawling.

The states on their part, with the reluctant consent of the Fisheries Division, often increased the number of trawl licences in response to pressure from lobbyists for the unlicensed trawl operators. Pressure from cooperatives which were keen to expand their tax base also led to increased issue of trawl licences every year except in 1977 (see Table 2.4). Nevertheless the number of unlicensed trawlers outgrew the increase in the issue of licences except in 1971 and 1973. For example, 4484 licences were issued from 1965 to 1978 but an estimated 1024 unlicensed trawlers, all of which operated off the west coast, remained in 1978.

2.11 Confrontation between Trawl and Non-Trawl Fishermen

The large inflow of licensed and unlicensed trawlers, most of which were prawn trawlers, heightened competition for the valuable prawn stocks between the trawlers and the operators of many small scale gear. Prawn stocks are mainly concentrated in depths less than 10 meters [Ong and Weber, 1977], well within the three mile boundary specified by the zone regulations. In view of the low rate of enforcement the prawn trawlers often found it more profitable to operate within the three mile limit after taking into account the risk and resulting cost of capture. Direct competition for prawn resources and operating space ensued. Violent confrontations between the trawl and non-trawl fishermen resulted. Between 1964 and 1976, a total of 107 vessels were destroyed and thirty four lives were lost in the confrontations [Goh, 1976, p.19]. Perak and Penang were the most sensitive areas; 84% and 11% of the incidents were reported to have taken place in them respectively.

Since 1976 similar confrontations have decreased for several reasons. A large number of the small scale fishermen had converted their vessels for trawling. Enforcement of the three mile delimitation by both the authorities and the small scale fishermen improved. In addition, trawlers were prohibited from operating in waters off Province Wellesley and a few other popular areas.

2.12 Fishing Cooperatives after 1965

The cooperative movement flourished with the right to control trawl licences. A number of the dormant cooperatives of the earlier schemes and numerous new cooperatives had been given trawl licences. Through their control over licences and associated taxation powers, most of the trawl cooperatives remained solvent and enjoyed sizeable stable memberships, at least through the mid 1970s. At the beginning of 1964, there were 76 fishing cooperatives registered in Peninsular Malaysia, 22 of which were not in operation and only 9 had records of the type of fishing units employed by their members. By 1975 the number of registered fishing cooperatives had decreased to 73 but there were 40 active ones 35 of which were trawl cooperatives. After 1975, the number of active and solvent trawl cooperatives gradually decreased [Yap, 1977b, p.18].

Despite what seemed to be improved performance on the part of the trawl cooperatives, they failed to achieve the goals set by the legislature. Indeed they were often detrimental to the management of fish resources. None of the trawl cooperatives actively marketed the landings of member vessels, or provided loans to members, or sold or supplied inputs below the market price. Most of them did not even provide basic infrastructure facilities. In short, they did not (and still do not) carry out the usual functions of cooperatives. Moreover, the objectives of racial balance of trawl crews and active participation by artisanal fishermen in ownership and operation of trawlers were ignored. Few investment projects were effectuated and those that were, particularly the purchase and operation of trawlers, had little success [Gibbons, 1976, pp.103-108].

The most harmful consequence flowing from the cooperative movement was the collection and submission to the Fisheries Division of incorrect statistics. After the initial few years, trawl owners had increasingly falsified or misrepresented the components of net incomes to the cooperatives in order to minimise taxes. This erosion of the tax base which provided the only source of assured income for the cooperatives led the cooperatives to lobby for more licences and illegal trawling was used as a major argument in its support. This being the case, there was no incentive to actively prevent illegal trawling. Similarly, zoning violations were ignored by the cooperatives because the more profitable inshore fishing brought higher taxes. Up until 1976, the Fisheries Division used the data on catch, effort and itemised cost and earning supplied by the cooperatives, unaltered, to estimate the official state and federal fisheries statistics on trawl gear. Such data relied on by the Fisheries Division was of course biased downwards for as early as 1969 trawl owners had begun to under-report catch, effort and fish price and over-report cost and the practice has according to several trawl owners, increased over the years.

The factors responsible for the failure of the two earlier cooperative schemes also accounted for their flagging successor. The cooperatives existed because of the regulations rather than the local fishermen's or trawl owners' desire. Boatowners joined them only to acquire the needed licences. Trawl crews threw in their lot to support particular political factions within the cooperative leadership and because they were paid a small fee to attend general meetings. The suppositions that underlay the older schemes remained unquestioned and equally unjustified. Available empirical analysis of the fishing industry to date, limited as it may be, has shown 1.the towkay system to be complex, flexible and adaptive with respect to the services it offered and in its response to economic opportunity. The monopsony powers of the towkays, in the larger fishing centres at least, too has been shown to be lower than that previously assumed; 2.that the requisite skills to operate a cooperative system which can supersede the towkay system could only be acquired on the job over a period of time; 3.that local economic and political elites which the very cooperative ideal sought to avoid, dominated the system for their own gains. The fishermen, even when they had the desire, had little ability to prevent them; 4.that the integration of a foreign institution into the traditional local socio-economic system, especially an unsound one, could not be left to local personnel or motivation. Direct government participation, leadership and funding were necessary.

The failure of the cooperatives and the relatively superior position of the Chinese fishermen in their adaptation of the trawl gear contributed to the under-representation of the Malays, in particular the Malay fishermen, in trawl fishing. The east coast, in 1978, had 35% of all registered fishermen (Table 2.1), 93% of whom were Malay, but only 17% of the trawlers (Table 2.3). The west coast states of Selangor and Perak in contrast had 60% of all trawlers and 30% of all registered fishermen, 80% of whom were Chinese. In the other large trawler state of Kedah/Perlis, Malays made up 75% of all fishermen in 1973 but only 35% of trawl crew and 40% of the more specialist positions. Malays fared much worse in the ownership of trawlers [Gibbons, 1976, p.105]. Gibbons [1976, p.104] estimated that over 90% of all licensed trawlers were owned by non-Malays in Penang and Kedah/Perlis. In the other west coast states, indications point towards a similar pattern in the racial composition of trawler ownership. A major reason for the under-represented Malay trawl ownership is that prior to 1965 the Chinese owned most of the purse seine, transport and large drift net vessels which could subsequently, because of their size, be converted to trawling. According to Nagata, [Gibbons,1976, p.104], there was also strong resistance to trawling in the Malay communities: Malay fishermen who switched to or crewed on trawlers suffered social sanctions.

Fishermen thus remained one of the most impoverished occupational groups in Malaysia despite the rapid growth of trawling. One reason for the continued impoverishment of the average fisherman is that, as shown in Table 2.5, 61% of all fishermen still employed unproductive small scale gear. The estimated catch per fisherman in small scale fishing units was only 3.26 m.ton, less than 25% of that in trawls and 33% of purse seine units. It has also been argued by several authors that over-fishing has led to a sharp decline in trawler incomes which in turn lower the average fisherman's income. The higher incidence of poverty recorded among the Malay fishermen may be attributed to their under-representation in trawl crews and ownership.

2.13 Majuikan

The Fisheries Development Board or Majuikan was set up in 1971 under the New Economic Policy. The objectives of Majuikan, like many of the parastatal corporations formed under the NEP, are not only to act as a channel for the expanded development funding allocated to fisheries but also to control directly, to operate and to instigate all facets of the development process. This marked a sharp transition in development philosophy, a departure from the assisted self-help theory of the fishery cooperative movement to a centrally controlled, all pervasive institution, under which the motivation, implementation and funding would be supplied by the government. The reasons for this transition (and for the transition evident in the

TABLE 2.5 : DISTRIBUTION OF CATCH, CATCH PER VESSEL AND CATCH PER FISHERMAN AMONGST GEAR TYPES IN 1978

	Large Scale Gear Trawl	All P.Seines	Small Sc. Gear	% of Total
No. of Licensed Vessels	5392	539	14384	71
Estimated Tot. No. Fishermen	21568 [1]	10780 [2]	51346[3]	61
Total Catch (m.t.)	285019	112634	167245	30
Catch per Vessel (m.t.)	52.86	208.97	11.63	
Catch per Fisherman (m.t.)	13.21	10.45	3.26	

Source : Annual Fisheries Statistics, 1979, Fisheries Division, Kuala Lumpur.
[1] Approximately 4 crew per trawler
[2] Approximately 20 crew per trawler
[3] Remaining registered fishermen

economy at large) included the persistent and politically intolerable impoverishment of the fishermen, particularly the Malay fishermen, the ineffectiveness of previous fishery development programs (specifically the cooperatives), and the desire for more speedy development. Under Majuikan three major types of programs were undertaken : 1. a large range of fishing enterprises and infrastructural developments, 2. Fishermen Associations, and 3. a subsidy scheme.

During the SMP and the first half of the TMP, Majuikan launched and operated 98 trawlers in Peninsular Malaysia. Seventy of these were located on the east coast and 15 in Kedah/Perlis, the most depressed regions. The intention was that Majuikan would profitably operate the trawlers, particularly on the under-exploited east coast, and in so doing would ensure the equitable participation of Malay and artisanal fishermen, the development of skills and experience necessary to set up a marketing network to compete with the towkays, and control of the number of trawlers in operation. In other words it was expected to achieve what the cooperatives failed to do. Unfortunately only 40 of the newly launched trawlers were operating in 1978 as a result of low net profit and high depreciation. The effectiveness of Majuikan vis-a-vis its avowed objectives was to this extent curtailed. Nonetheless Majuikan plans to launch and operate up to 200 trawlers on the east coast and 30 multi-purpose vessels on both coasts during the Third Malaysia Plan (TMP)[Malaysia, 1976, p.302]. Majuikan has also moved into the operation of various support industries such as ice factories, prawn processing, marketing bodies, fish meal plants and transport facilities. Like the trawler programs, funding and the initiation of new projects in the support industry programs are increasing despite a history of substantial financial losses and the bankruptcy of many individual projects.

In 1971, the Fishermen's Association was set up as a sister body to the Farmers' Association movement which was initiated in 1969. The two associations are based on the Taiwan model which is a hierarchical organization of fishermen groups or associations. For these the ideas, funds and staff are supplied from a federal body through the states to the local authorities. The long term objective of the associations is to inculcate and develop the cooperative spirit of the artisanal fishermen in order that fully-functioning cooperatives may eventuate. In the short term, the main aim is to provide an institution through which subsidies and loans may be effectively granted.

Since 1976 the Fishermen's Association has begun to amalgamate with the fishing cooperatives that have continued. This was not without resistance from the more solvent and politically powerful cooperatives which fear the usurping of their jobs and power. Nevertheless Majuikan and the Fishermen's Association will eventually control all existing trawl cooperatives and all trawl licences.

A capital subsidy scheme was begun in 1976 to provide loans and subsidies to small scale (non-trawl and purse seine) fishermen for the purchase of vessels and equipment. Administered by the Fishermen's Association, it is open to members who are full-time fishermen and who operate small scale gear. A total of $70 million was allocated for this purpose between 1976 and 1980, most of which has been spent on the east coast and Kedah/Perlis [Malaysia, 1976, appendix II]. The subsidies and loans were limited to vessels of less than 8 horsepower to avoid indirectly adding to the illegal trawl fleet. Even then, as the subsidies increase fishing intensity, especially on the prawn resources, competition between trawlers and non-trawlers will correspondingly increase.

2.14 Public Data Base

The inaccuracy and scarcity of published data on trawl catch, effort and other economic data rendered impossible even the most superficial assessment of the biological and economic conditions of the trawl fisheries. The only annually collected and published data on the trawl fishery are those obtained from the cooperatives and the Fisheries Division. However, there have been a few cross-sectional studies of the trawl industry which collected data independently of the cooperatives and the Fisheries Division. With the exception of the U.S. Peace Corps cost and earning study of 1969 [Peace Corps, 1970], all these studies have been restricted to a very limited time span (a few months at most), specific areas and have been based on respondent recall rather than direct observation. Furthermore, with the exception of the trawl surveys carried out on the west coast in 1970/1971, 1971/1972 and 1974, and four similar ones on the east coast by the Fisheries Division, there has not been any yearly time series data collected or published apart from that made available by the cooperatives.

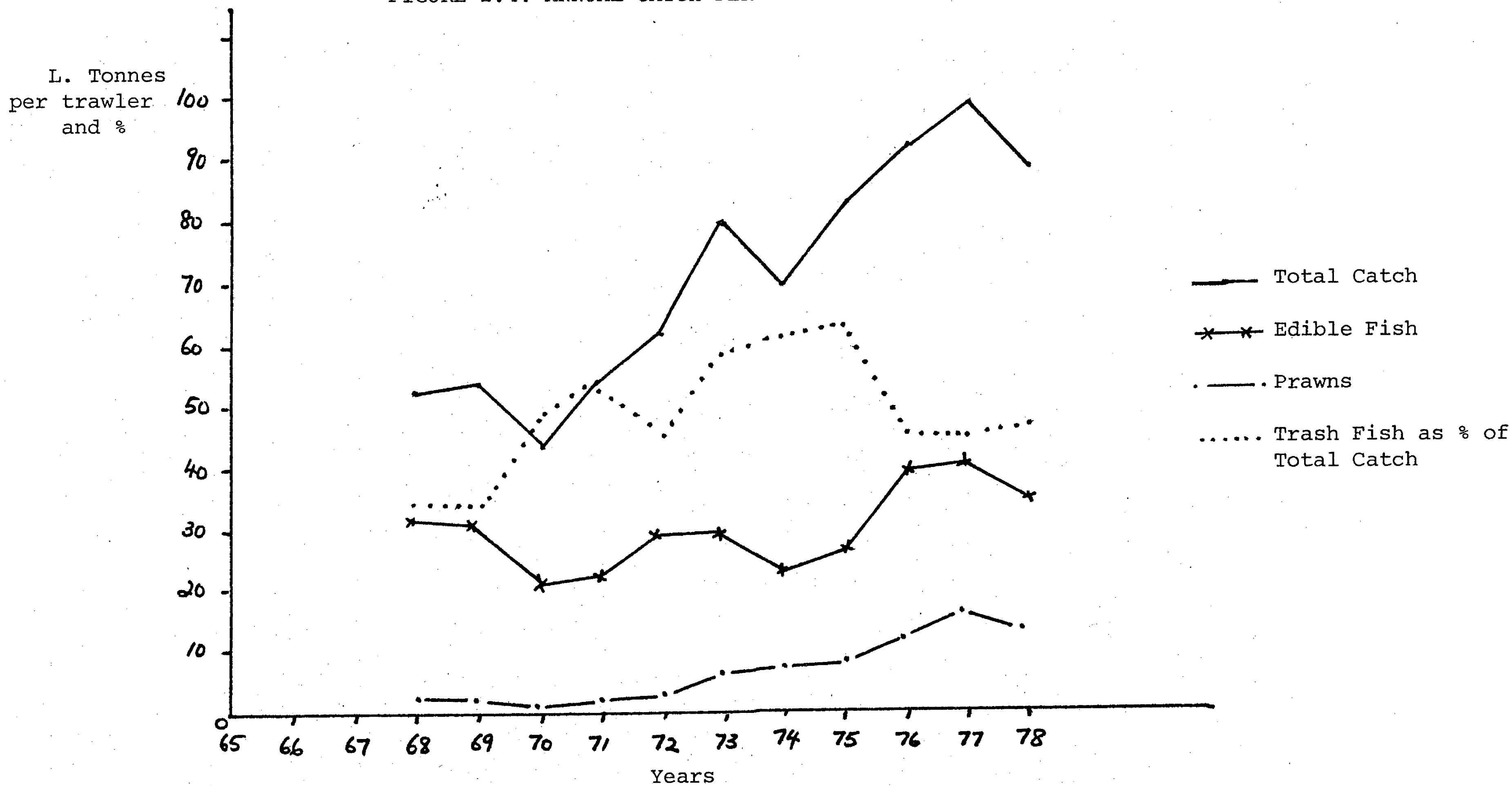
Data from the cooperatives since 1969 and those from the fisheries division between 1969 and 1976 are known to be unsystematically biased and therefore unreliable. The cooperatives' data from 1965 to 1968 are reasonably accurate, though often no longer available. The Fisheries Division's data after 1976 are more questionable. In 1976 the Fisheries Division began estimating the total trawl catch by an unstructured sampling program. The district fisheries officers would sample a few trawl catches per month and use them to estimate the total monthly catch for all trawlers estimated to be operating in that district. This sampling procedure has been recognised to be faulty and the sample to be unrepresentative. The sample was often too small and had often led to the collection of falsified data. The local officers had to collect catches and issue licences for all gear types as well as to perform many other administrative and regulatory functions. They thus had little time and often little motivation to ensure unbiased samples. In 1978 a new FAO developed sampling framework was introduced and a fishery officer was stationed in each state whose sole function was to collect catch data. Under this new framework the total catch is estimated with a random sample stratified by tonnage of vessel, week of month and port. Although the catch data thus collected are more accurate than what had been obtained before, the degree of its accuracy still remains to be ascertained.

Data on the physical description of the trawlers, and their temporal and spatial operations necessary to determine accurately the fishing effort, is very limited. The Fisheries Division collects data annually on the tonnage, engine size and engine type of each licensed trawler. Unfortunately this information is improperly identified for the large number of unlicensed trawlers operating off the west coast. Estimates of the temporal application of trawl effort through 1975 were derived from the trawl cooperatives' data and are biased. After this time the Fisheries Division collected their own estimates along with the catch data, but their estimates are subject to the same criticisms.

Accurate published economic data on the trawl fisheries over and above the Peace Corps (1970) study is almost non-existent. The trawl owners have been and still are generally reluctant to divulge information, particularly to government officers, concerning their income for fear that such information may be relayed to the income tax department. The commonly encountered caution with which businessmen regard their business 'secrets' also accounts for their suspicion.

Notwithstanding the deficiencies and inaccuracy of secondary data on trawl fisheries, studies which attempt to assess their biological and economic conditions have been published based on such data. These studies used mainly pre-1973 data supplied by the cooperatives and found, unanimously, that the trawl fishery on the west coast was biologically and economically over-exploited [see Yap, 1977; Koo, 1976]. As illustrated in Figure 2.4, their case turns on the fact that the total catch per trawler as estimated by the Fisheries Division decreased sharply between 1968 and 1972. During this period too, it was noted, the trash fish or 'ikan baja' share of total catch fluctuated around 50% resulting in the decrease of edible fish catch per trawler from 20 to 5 long tons per trawler. This data when fitted to a surplus production model gave estimates of maximum sustainable yield (MSY) of total catch to be between 90 and 103 thousand long tons [Pathansali,1976]. The total trawl catch was 93,447 long tons in 1972 and this roughly matched the MSY. The high proportion of trash fish, the argument goes, indicated severe over-fishing. However, none of the studies analysed the composition of trash fish landings. The estimates of net income and wages obtained from the cooperatives were also used to support the case of over-fishing or at least its imminence. The return to capital by 1971 was

FIGURE 2.4: ANNUAL CATCH PER TRAWLER BY MAJOR CATCH CATEGORIES



Source: Annual Fisheries Statistics, 1969 - 1979.

estimated to be equal to or below its opportunity costs as were the return to labour [Munro and Chee, 1978].

Estimates by the fisheries department of total catch, edible catch and trash fish after 1973 clearly refute the findings just discussed as shown in Figure 2.4. Total and edible catch increased steadily after 1972 and by 1977 they equaled their respective 1968 levels. Total trawl catch was 222,881 long tons (over twice the MSY), an impossibly high catch level if the MSY was correct. Trash fish remained at about 50% of total catch. An important result hitherto little noticed in the literature was the stability of the estimated prawn catch per trawler throughout the 1968 to 1978 period. Since the majority of trawlers concentrated on harvesting prawns, the absence of any decline in the prawn catch rate would seem to indicate, given the rapid increase in prawn prices during this period, that a large proportion of the total trawl fleet had remained profitable.

Central to the problem was of course the use of biased data which could only give biased results. As the only data available were those provided by the cooperatives, researchers had little choice in the short run but to rely on them. Some assessment of the trawl fisheries had to be made for the formation of policies in the face of the increase in trawler numbers and there was always the desire to enhance the fishermen's incomes. The decline and recovery of the west coast trawl fishery between 1968 and 1978 as seen in the official statistics is more in the order of a statistical illusion than a mapping of the stock abundance. The argument of over-fishing, which the data prima facie support, had seemed plausible given the large continual inflow of trawlers operating in a rather limited area. This was particularly so when seen in conjunction with the over-exploitation of trawl fisheries in the Gulf of Thailand, and in the light of biological and economic theory.

2.15 Summary

The marine fishing industry in Peninsular Malaysia has evolved a dualistic structure in a manner similar to the nation's economy at large. A capital intensive, productive sector developed, owned and primarily operated by Chinese off the west coast states, has dominated the industry in terms of total marketed catch and remuneration to factors of production. On the other hand there exists a large body of fishermen, predominantly Malay and concentrated on the east coast, who employ unproductive, low income generating artisanal fishing units. The large scale sector has proven to be very responsive to technological, economic and institutional opportunities and restrictions. The artisanal sector has benefitted from numerous technological and economic advances introduced by the large scale sector, but relative to it and to the economy as a whole, the economic state of artisanal fishermen has not improved.

Marine fishery management programs have a 60-year history in Malaysia. A vessel and gear licence scheme, together with prohibitions of certain gear types and restrictions on the spatial and temporal and physical dimensions of fishing effort, was instituted at various times to control the development of the large scale sector. Cooperatives, associated loan programs and marketing schemes too were thrown in to accelerate the development of the artisanal sector. Neither the development nor the control programs have been successful. The absence of an effective management program has resulted in the expansion of the trawler fleet to a level at which over-fishing is probable. The chasm between the two fishing sectors has not been bridged despite the NEP and the range of development programs. However, an institutional structure exists in the form of the Fishermen's Association under Majuikan, which has rein over two management control variables, that is, licences and licence fees.

CHAPTER 3

SELECTION OF STUDY SITE, DATA COLLECTION PROCEDURES AND ASSESSMENT OF DATA BASE

3.1 Choice of Study Site

This thesis focuses on the trawl fishery of the Kedah/Perlis [1] region of Malaysia (see Map 1) for the following reasons. In the face of constraints which included the 'data-intensive' demands of bionomic modelling, the paucity of data on the Malaysian trawl fishery, and limited financial and human resources, it was necessary to confine research to one demarcated region. Accordingly, all major marine fishing centres in Peninsular Malaysia were surveyed, pertinent publications were examined and discussions were held with knowledgeable and informed parties in December 1978 and January 1979 in order to determine the most suitable site for the proposed study. Kedah/Perlis was chosen, consistently with the objectives of the research, on the basis of 1) the political feasibility of instituting a trawl fishery management program, 2) the availability of original time series-cross section and published data, 3) her large number of trawlers concentrated in a few ports, and 4) the least biological and/or economic competition from trawls, local or otherwise, based outside its site.

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[1] Kedah and Perlis are the two most northern states on the west coast of Peninsular Malaysia. Although they are individual states, the federal government administers them as a single region. Therefore they will be treated as such throughout the study.

It is proposed to discuss in this chapter the relevant aspects of the study site and associated matters of data collection and assessment.

3.2 Description of the Study Site

Kedah/Perlis is the most economically depressed region on the west coast and has the highest incidence of poverty and the lowest GDP per capita on the west coast. Correspondingly, the region's economy is inordinately based upon the production of primary products from small scale units; mainly paddy in the wide coastal plain, rubber in the central foothills and marine fishing at the larger river mouths. The population is predominantly Malay (71%) [Economic Consultants, 1978, p.A-12] with the Chinese concentrated in the urban centres, particularly in Alor Star, Kuala Kedah and Sungai Petani. Registered unemployment is estimated to be lower than the national average, but seasonal under-employment is said to be characteristic of about 50% of the region's labour force [Economic Consultants, 1978, p.B-81].

Like the east coast states of Kelantan and Trengganu, Kedah/Perlis has been identified as a priority region under the NEP because of its depressed condition and the predominance of Malays. Nonetheless, the $1.2 billion [Malaysia, 1979, App.I] in development funds allocated to the region under the revised TMP, is the lowest expenditure per capita in the federation. The justification for this apparent inconsistency is that the absence of unexploited natural resources and the limited expansion potential of her industrial sector, relative to the other states, restrict her returns to development spending which already trails behind that of the other states. It is therefore preferrable, the argument goes, to allocate a greater portion of total development funds to the "higher return" states, and to leave the population of Kedah/Perlis to benefit from migration, remittances and governmental transfer payments.

The largest portion of development funds allocated to Kedah/Perlis has been channelled to agriculture and fisheries. Fisheries received \$23.19 million under the revised TMP development funding (as compared to \$39.7 million under the original TMP) on the grounds that the fishing sector's resource base and its institutions have a poor effective absorptive capacity. Since the potential for productivity gains through increased exploitation of natural resources was believed to be limited, efficiency related programs, e.g. marketing and credit, have received most of the agricultural and fisheries development allocation.

The industrial sector, including the parastatal corporations, received the second largest allocation of development funds after agriculture and fisheries. However, as in the fishing sector, the total allocation to the industrial sector was reduced from \$192 million under the original TMP to \$162 million under the revised TMP, as a result of the limited growth capacity which is also lower than is initially expected or desired [Malaysia, 1979, App.I].

In the absence of a well defined migration policy, inter-state migration, particularly the unorganised variety, must be relied upon as a major tool in meeting the equity and productivity goals of the NEP. The depressed regions such as Kedah/Perlis would only become more backward without large scale migration. The Kedah/Perlis Development study carried out in 1976/1977 [Economic Consultants, 1978, p.C-21] predicted that even if the manufacturing sector directly and indirectly created 30,000 additional jobs by 1990 (a figure in excess of what can be expected) there will still be approximately 105,000 or 10% of the projected population aged 15-64 in 1990 unemployed in the region. The report further states that "we (the consultants) see no prospect that the gap between projected workforce and the number of jobs can be closed without migration on a large scale out of the study area (Kedah/Perlis)" [Economic Consultants, 1978, p.C-21].

The rate of migration from Kedah/Perlis to the more rapidly developing states, i.e. Selangor, Johore, Pahang and Penang, will to a large extent depend upon the growth and composition of its industrial sector. Since 1971, the industrial sector, particularly the export oriented industries, has been able to achieve a growth rate adequate to absorb an increasingly larger share of the labour force. Nevertheless, any displacement of fishermen resulting from rationalisation of the trawl fishery will add to the already large pool of potential migrants. The future absorptive capacity of the industrial sector in Kedah/Perlis and other states with surplus labour should be explicitly considered in the bionomic modelling process.

3.3 Feasibility of Instituting a Trawl Fishery Management Program

The economic inertia of Kedah/Perlis, her visibly Malay population that is deemed deserving of political concern, and its trawl fishery together makes a convincing case for the institution of a fishery management program.

The state of ownership in the Kedah/Perlis trawl fishery (at least as ascertained prior to this study) generates minimal conflict between, on the one hand, the objectives and programs of the NEP, and, on the other, bionomic management of the fishery's resources. Indeed, there is a high degree of complementarity between them. For instance, the Kedah/Perlis trawl fishery, like those in the other west coast states, is predominantly Chinese-owned such that a reduction in the number of trawlers would not directly conflict with the Malay ownership goals of the NEP.

Interestingly, the pattern and condition of labour supply too facilitates, in a curious way, the institution of a fishery management program. The trawl crews in Kedah/Perlis, unlike those in the other west coast states, are allegedly mainly Malay and reports have it that there is a high incidence of poverty (albeit not as high as among the small scale fishermen [Munro and Chee, 1978, p.49]) among them. The resulting characterisation of Kedah/Perlis trawl crews as impoverished Malays indentifies them as a primary recipient of the NEP assistant programs. This effectively means the availability of required funds. At the same time, the general priority accorded to the region would lend support to a management program by increasing opportunities open to the population thereby directly or indirectly helping to absorb the fishery's redundant fishermen and capital.

Yet another argument for fishery management stems from the accepted assessment that the trawl fishery stocks are over-fished (see Chapter 2). This portends further stagnation of crew and trawl owner income, a state of affair for which management is a means of redress that also meets the policy criteria of the NEP and the development strategy followed in Kedah/Perlis.

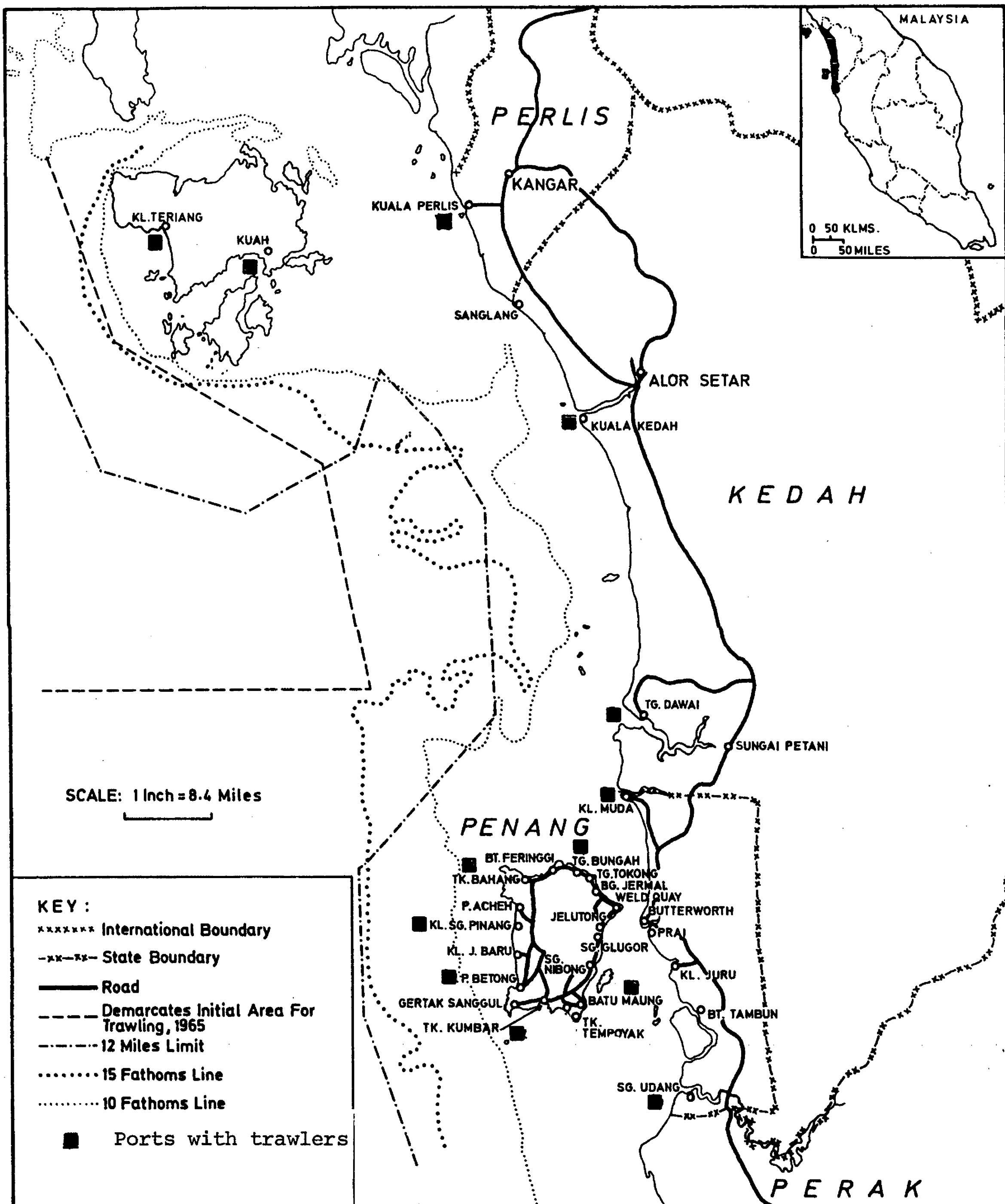
3.4 Availability of Data

Chinese market agents and larger scale boat owners are known to keep detailed records of their clients' trawlers as well as their own but these records have seldom been made available to researchers or for that matter been actively sought by them primarily because of mutual distrust. The market agents in Kuala Kedah, however, have been most co-operative in providing access to their records. To date, most of the research carried out on the large scale fishing sector has focused on Kuala Kedah and the market agents have had a long association with a continuous stream of researchers and some able and well respected government officers.

3.5 Diversity and Size of Kedah/Perlis Trawl Fleet

The Kedah/Perlis trawl fleet exhibits the greatest potential for yielding a robust set of time series-cross section data. The Kedah/Perlis trawl fleet is the third largest after those of Perak and Selangor, with 637 licensed trawlers in 1978. The Kedah/Perlis trawl fleet is also the oldest and most diverse in terms of vessel size and catch composition (see Chapter 2). The latter characteristics meant that this fleet offered the best opportunity for an examination of the full range of trawler technology used and available in Malaysia. Furthermore, the largest concentration and number of fish trawlers, which form the subject of this study, is located in Kedah. More specifically, the Kedah/Perlis trawl fleet is concentrated in only four ports: Kuala Perlis, Kuah on Langkawi Island, Kuala Kedah and Tanjong Dawai (see Map 1). Kuala Kedah was subsequently chosen as the study port because it provided adequate representation of all

MAP 1: KEDAH/PERLIS AND ADJACENT TRAWLING PORTS



Source: Munro and Chee, 1978, p.vii

trawler sizes, types, and fishing grounds and had over 80% of the licensed trawlers in Kedah/Perlis. Moreover, it is the only port in the study area to have an active trawl fleet before 1970. Tanjong Dawai and its 26 fish trawlers owned by two market agents and a trawl cooperative had to be excluded from the study when the boats owned by the cooperative became bankrupt and the market agents refused to cooperate. Kuala Perlis and Kuah have only small prawn trawlers which operate in the same area and in the same manner as those stationed in Kuala Kedah.

3.6 Biological and Economic Interaction

The trawl fleet in Kedah/Perlis is relatively free of biological and economic competition from non-local fishing units. The inflow of non-local trawlers and the outflow of local trawlers are restricted by institutional, economic and other constraints. For instance, Thai pirates effectively prevent Kedah/Perlis trawlers from operating in Thai waters while the presence of Malaysian patrol vessels restricts Thai intrusions into Kedah/Perlis waters to a few coral reef bombers. The relative richness of the Thai waters also make risky intrusions into the Kedah/Perlis waters less attractive. On the southern front, trawling is prohibited off Province Wellesley, the mainland portion of Penang state, by government edict and this prohibition is enforced with the unsolicited assistance of the local small scale fishermen.

The Penang Island trawl fleets which are in a rapid state of decline [2], have, from the beginning, confined themselves [Peace Corps, 1970, p.16] to the near-shore areas of the island in search of prawns. Penang thus provides a demarcation zone between Kedah/Perlis and the other west coast states which, along with their own regulations for the operation of trawlers (see Chapter 2) effectively curtails the exchange of trawlers between Kedah/Perlis and the other states. All trawlers operating in Kedah/Perlis waters are therefore based in Kedah/Perlis, a condition not found in Selangor or Perak.

Competition posed by other types of gear units in Kedah/Perlis is not grave. Only part of the small scale gears compete with the trawl gear for the demersal or semi-pelagic fishery stocks. The small scale sector is composed of a large range of gear types which in turn exploit all dimensions of near-shore ecosystem. Besides, the small scale fishing sector in Kedah/Perlis is very small relative to the large scale sector and is even more so than those in the other states. As shown in Table 3.1, the large scale fishing sector in Kedah/Perlis, defined here to include licensed purse seines and

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[2] The total trawl landings for Penang state, as estimated by the Fisheries Division, has decreased from 10,141 metric tonnes in 1974 to 3,531 metric tonnes in 1979 with a decrease in the estimated number of trawlers during the corresponding period from 219 to 196. From discussions with trawl owners and co-operative officials, it appears that the decrease in trawl landings and trawlers is a true indication of the decline of the trawl fisheries and is not a mere statistical illusion.

TABLE 3.1 : PERCENTAGE OF TOTAL MARINE LANDINGS [1] AND FISHING UNITS [2] ACCOUNTED FOR BY LARGE SCALE UNITS [3] IN KEDAH/PERLIS AND THE WEST COAST IN 1970, 1974 AND 1978

	Large Scale Units as % of all Fishing Units		Large Scale Units as % of total Marine Land.	
	Ked/Per	W.Coast	Ked/Per	W.Coast
1970	36	31	61	45
1974	45	42	79	57
1978	40	30	97	71

[1] Annual Fisheries Statistics, 1971, 1975, 1979.
[2] Estimated Fishing Units in Operation from the Annual Fisheries Statistics, 1971, 1975, 1979.
[3] This includes trawlers, all types of purse seines and large stakes.

trawlers, has always made up a greater proportion of the total estimated number of fish units in Peninsular Malaysia than of the large scale sectors of the west coast as a whole. More importantly, the large scale sector in Kedah/Perlis accounted for 97% of its total estimated marine fisheries harvest in 1978 and has accounted for over 60% of it since 1970. This was consistently greater than the total west coast ratio.

3.7 Trawler Types

From preliminary discussions held with government officials, co-operative officers, market agents and fishermen during January and February 1979, it was possible to identify three distinct types of trawlers operating from Kedah/Perlis ports: the Small Prawn Trawl (SPT) vessels, the Pulau Ketam Trawl (PKT) vessels, and the Fish Trawl (FT) vessels. These trawler types were distinguished on the basis of target species, average length of trip, size of engine and vessel, type of ownership and marketing arrangements.

3.8 The Small Prawn Trawlers

The Small Prawn Trawlers are operated from Kuala Perlis, Kuah and Kuala Kedah on nightly trips and they concentrate on the prawn stocks in the near-shore areas. The SPT vessels which vary in size between 4 to 25 gross tonnes with engines between 16 to 140 horsepower are characteristically owned and operated by local Chinese and Malays. The Chinese owners dominate but the number of Malay owners is on the increase particularly in the smaller horsepower and tonnage classes. The SPT owners always sell their catch locally to one of the assemblers [3] or market agents [4] or directly to one of the two local prawn processors rather than consign their catch directly to an out-station market. The market agent, depending on the degree of the 'tied' relationship, will provide capital and loans, directly supply inputs, supply credit for all inputs, supply institutional and legal assistance and maintain records in exchange for the right to purchase the catch. In the beginning of 1979, there were 14 established market agents in Kuala Kedah (3 Malays and 11 Chinese) as well as a large fluctuating pool of assemblers.

3.9 Pulau Ketam Trawlers

The Pulau Ketam trawlers are prawn trawlers owned and operated by 'Teo Chew' Chinese originating from Pulau Ketam off Selangor [5].

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[3] An assembler is defined as a person or firm who purchases the catch or a portion thereof directly from a fishing unit owner or from the other assemblers without any loan or service provided, but rather purchases solely on the basis of a competitive price.

[4] For purposes of this study, a market agent is defined as a firm or individual who enters into an arrangement with a fishing unit owner under which the owner, in exchange for loans and other services, agrees to sell all or a portion of every catch to the marketing agent as long as there are loans outstanding.

[5] They are formerly migratory drift net fishermen from Pulau Ketam (see Chap.2) who have switched to trawling and who, because of the regulations governing the geographic employment of trawlers, have become permanently stationed in Kedah.

This trawler type operates 3-4 day trips; fishing at night and anchoring in the lee of the various islands during the daylight hours. The PKT vessels, all of which are stationed in Tongkong Yard five miles up-stream from Kuala Kedah, cover the entire range of vessel and horsepower size found in the trawl industry.

The PKT owners are tied to a single PKT market agent and this association is very stable when compared to that between the SPT owners and their market agents. The market agent provides the full range of loans and services in exchange for rights to purchase the entire catch. There were 11 PKT market agents in Kuala Kedah in 1979, eight of whom were former PKT owners from Pulau Ketam. The other three local market agents were the parties who, through their local contacts and knowledge, brought the migratory Pulau Ketam fishermen and their trawlers to Kedah/Perlis.

3.10 Fish Trawlers

Fish trawlers are larger 20 gross ton vessels with engines of more than 80 horsepower. This trawl type harvests a wide range of demersal and semi-pelagic fish species, molluscs, brachiopods, and prawns. Fish trawlers operate from Kuala Kedah and Tanjong Dawai on one day trips during the daylight hours, except when they switch to night trawling for prawns.

The majority of fish trawlers are owner-non-operators, with the owners carrying out the marketing and other shore management functions. The owner hires a captain or 'taikong' and an engineman. The captain, in turn, is responsible for hiring and management of the crew. The distribution of trawler income between owner and crew is determined by a 50% lay system called <u>bagi dua</u> where the crew, which includes the captain and the engineman, and the owner each receives 50% of the total revenue net of costs. The settlement called panggu is calculated every 2-6 weeks depending on the value of the harvest. The crew receives, over and above their share, various other payments for their services which will be discussed in Chapter 7. The FT owners also receive income in addition to their share. The FT firm acts as a vertically integrated enterprise encompassing the harvesting and the initial marketing processes. The firm manager after receiving a set of prices from the sale of the catch, divides the total revenue between marketing and harvesting by administering a set of ex-vessel prices. The boat-level price is the price used in the panggu for derivation of the lay. The relationship between the market price and the ex-vessel price will be discussed in Chapter 7. Here it is sufficient to point out that the market price is reported to be on the average 15% to 50% greater than the ex-vessel price. The FT firm thus receives marketing revenue which is the difference between marketing and ex-vessel prices in addition to share income.

Prawn trawlers also use the bagi dua system. However, because the prawn trawlers are largely owner-operated with the catch sold at the jetty to market agents or assemblers, there is no difference between the prices received by the owner for the sale of the catch and the prices used in the panggu. In other words, there is no administered ex-vessel price.

3.11 Primary Trawler Types

After identifying the various trawler types we were forced by limited resources to focus on the FT fleet. The choice of the fish trawlers rather than the prawn trawlers was based mainly upon the differences in the inter-temporal growth characteristics of their respective target species. Unlike the growth processes of a fish stock outlined in Chapter 4, recruitment of a given prawn population is generally unrelated to size of the parent stock. The prawn population in a given year depends primarily on various ecological conditions during critical phases of its life cycle and little upon the population size in previous years [Anderson, 1977, p.23]. Thus biological over-fishing is not a basic problem. The management of a prawn fishery is therefore basically the rationalisation of excess or suboptimal resources applied to the fishery resulting from the absence of property rights.

It was recognised that fish trawlers competed with prawn trawlers biologically as well as in the product and factor markets. Admittedly too, many fish trawlers seasonally switched to trawling to prawns and could easily convert to full time prawn trawling if returns to fish trawling become comparatively low. Consequently although the FT fleet was chosen as the object of the study, biological and economic data on the prawn trawl fleets were collected in order to examine the degree of competition posed and the opportunities offered to the fish trawlers.

3.12 Information Requirements

The availability of an extensive data base is essential to a bionomic assessment of a capture fishery. The published data concerning the Malaysian trawl fishery is, as has already been seen, neither sufficiently accurate nor complete to permit such an assessment. Therefore, a primary objective of this study was to procure from original sources such a data base. The requisite data set must be composed of the following three basic types of information:

1. an accurate estimate of the number of trawlers operating in the Kedah/Perlis waters since the introduction of trawling,
2. a qualitative and quantitative description of the structure and conduct of the trawl fishery as well as its component product and factor markets, and
3. a representative time series-cross section data set on
(a) catch composition,
(b) technical, temporal and spatial dimensions of fishing effort,
(c) itemised costs, and
(d) fish prices.

3.13 Size and Composition of Trawl Effort

After selecting the study site, the task in the field was to establish an accurate estimate of the total size and composition of the trawl fleet at the study site since the introduction of trawl gear in 1965. This included estimating the number of illegal or unlicensed trawlers per trawler type per year.

Each state's fisheries office collects and publishes annually detailed data on all licensed fishing vessels. This data, published in the Annual Boatlist [Annual Boatlist, 1968-1979], include the following information:

(a) vessel licence number,
(b) port and fishing district,

(c) vessel dimensions - width, length, depth, and tonnage,

(d) type of propulsion units, i.e. no engine, inboard engine or outboard engine,

(e) engine make,

(f) engine horsepower,

(g) major gear,

(h) minor gear, if any,

(i) crew size for major gear, and

(j) racial composition of the crew (only after 1978 in Kedah/Perlis)

Apart from items (g) to (j), this vessel licence information furnished by the licensed trawl owners and available from 1968 to 1979 is relatively accurate.

However, we were informed by vessel owners that some trawlers were operated without the requisite licences and falsification of data on crew size and racial composition was not unknown [6].

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[6] A group of Fisheries Division officers personally measures and checks the dimensions of each licensed vessel each time the licence is renewed. The members of the group are changed periodically to minimise corruption. Some corruption was nevertheless reported by the FT firms interviewed. This it seems was because some trawl owners switched to a different size hull without informing the Fisheries Division. In the vessel survey set (Ques. 05) we collected time series information on the hull and engine dimensions of all sampled trawlers. The dimensions in the Annual Boatlist seldom differed from the sample information.

All fishing vessels are required to obtain a vessel licence which automatically necessitates obtaining a gear licence. Fishing vessels, particularly the larger motorised trawlers in the major ports, without valid vessel licences are easily identified. Since a major revenue source for the Fisheries Division was licence fees, enforcement of the vessel licence regulations have been strict.

All trawlers, with or without trawl gear licences have had valid vessel licences and were included in the Annual Boatlist.

Each district's fisheries officer in Kedah/Perlis has since 1968 produced estimates of the total number of trawlers, including unlicensed trawlers, operating from his specific district. These estimates, which are based on educated guesses, are insufficient for two reasons. Firstly they do not provide a breakdown of unlicensed trawlers by trawler type or size. Secondly these estimates, it is generally agreed, are inconsistent from year to year and tend to under-state the true population of active trawlers.

To rectify the misidentification in the Boatlist of unlicensed trawlers as a result of the misrepresentation of gear-types, several knowledgeable and co-operative market agents and trawl owners individually examined each Annual Boatlist, to identify all unlicensed trawlers in his trawl type specialty. Each individual's results were then discussed and compared with those of other respondents of the same trawl type specialty, and concensus estimates of the total number and composition of unlicensed as well as licensed trawlers were arrived at.

The accurate identification of the major unlicensed trawlers in the Annual Boatlists was facilitated by the geographical concentration of the industry and the market agents. Most of the unlicensed trawlers were located in the main port of Kuala Kedah. Kuah and Tanjong Dawai on the other hand, did not have any type of illegal trawler whereas Kuala Perlis had only small prawn trawlers representing only 30% of the total SPT numbers. Illegal trawlers were prevented from operating in Kuah and Tanjong Dawai by the predominantly Malay small scale fishing communities.

The explanation advanced by the examiners was that the enforcement agents focused their efforts on the larger owner-non-operator fish trawlers to the extent of removing any incentive to operate an unlicensed fish trawler [7]. The small number of unlicensed fish trawlers in the years prior to 1974 was easily identified by the 17 FT owners examining the Annual Boatlists. Again, the history of the FT vessels, both licensed and unlicensed, was verified later in the discussions held with all firms owning fish trawlers.

Unlicensed small prawn trawlers were the most difficult trawl type to identify. The large number of SPT vessels located in two ports and the proliferation of market agents made it impossible to interview all SPT market agents and owners, or for that matter, even to procure a sample of SPT market agents or owners able to accurately identify the SPT fleet from the Annual Boatlists. The identification

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[7] In other words, the opportunity costs of purchasing and operating a large trawler has exceeded the expected returns of even an above average fish trawler when the expected cost of capture is included.

process was further hindered by the limited duration of ties between trawl owners and market agents and the wide range of vessel and engine sizes used by small prawn trawlers.

However, a restricted amnesty, given in Perlis during 1978 and in Kuala Kedah and Langkawi during 1979 to SPT owners, provide an accurate estimate of the number of small prawn trawlers operating in Kedah/Perlis as well as a list of the vessels that had operated an SPT illegally in previous years. Trawl licences were issued to all local SPT owners who in previous years had personally owned and operated an unlicensed trawler of less than 25 tons.

Seven SPT market agents from Kuala Kedah and two from Kuala Perlis helped to identify small prawn trawlers listed in the Annual Boatlists. The list of small prawn trawlers licensed under the two amnesty programs was treated as a complete register of the SPT population and used as a starting point to trace the history of each small prawn trawler. The fact that most of the small prawn trawlers increased their engine size just prior to taking up trawling provided an important means to their identification. Changes in engine size which could be determined in the Annual Boatlists also enabled us to determine the year in which the vessel switched to trawling. The resultant estimate of the SPT population, particularly in earlier years, is less accurate than those of the FT and PKT populations. Nevertheless, it should be sufficiently accurate for the purpose of this study.

The estimates of the number of small prawn trawlers, Pulau Ketam trawlers, and fish trawlers as categorised by horsepower class and year are given in Tables 3.2, 3.3 and 3.4 respectively.

TABLE 3.2 : NUMBER OF OPERATING SMALL PRAWN TRAWLERS AND BOAT-YEARS OF SPT PANGGU AND TRIP RECEIPT DATA OBTAINING EACH YEAR FROM 1965 THROUGH 1979 CATEGORISED BY HORSEPOWER CLASS

Year	Sample Type	0-19	20-39	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	Total	% of Total
1967[1]	Total	23	1	-	6	13	-	-	-	-	-	43	-
	Panggu	-	-	-	-	-	-	-	-	-	-	-	-
	Receipt	-	-	-	-	-	-	-	-	-	-	-	-
1968	Total	31	2	-	6	15	4	-	-	-	-	58	-
	Panggu	-	-	-	-	-	-	-	-	-	-	-	-
	Receipt	-	-	-	-	-	-	-	-	-	-	-	-
1969	Total	21	44	3	6	24	4	2	-	-	-	104	-
	Panggu	1	-	-	-	1	-	-	-	-	-	2	2%
	Receipt	-	-	-	-	-	-	-	-	-	-	-	-
1970	Total	32	26	9	18	41	14	8	1	-	-	149	-
	Panggu	-	-	-	-	-	-	-	-	-	-	-	-
	Receipt	-	-	-	-	-	-	-	-	-	-	-	-
1971	Total	32	87	15	24	36	13	11	1	-	-	219	-
	Panggu	-	-	-	-	-	-	-	-	-	-	-	-
	Receipt	-	-	-	-	-	-	-	-	-	-	-	-
1972	Total	31	129	25	31	22	13	12	1	-	-	264	-
	Panggu	-	3	-	-	-	-	-	-	-	-	3	1%
	Receipt	-	2	-	-	-	-	-	-	-	-	-	-
1973	Total	34	120	24	23	22	30	11	7	-	-	271	-
	Panggu	-	-	1	-	-	-	-	-	-	-	1	0.5%
	Receipt	-	4	-	-	-	-	-	-	-	-	4	1.5%
1974	Total	37	94	20	15	21	38	14	9	-	-	248	-
	Panggu	-	-	1	-	-	-	-	-	-	-	1	0.4%
	Receipt	-	3	-	-	-	-	-	-	-	-	3	1%
1975	Total	41	114	24	12	15	31	18	9	-	-	264	-
	Panggu	-	8	3	-	-	-	-	1	-	-	12	4.5%
	Receipt	-	8	-	-	-	-	-	-	-	-	8	3%
1976	Total	31	122	27	13	13	35	13	12	-	-	266	-
	Panggu	2	15	4	-	-	1	-	3	-	-	25	9%
	Receipt	1	14	1	-	-	-	-	1	-	-	17	6%
1977	Total	38	193	16	6	11	38	18	15	-	-	335	-
	Panggu	3	16	4	-	-	1	1	5	-	-	30	9%
	Receipt	3	14	1	-	-	-	-	3	-	-	21	6%
1978	Total	46	271	16	5	8	26	18	15	-	-	405	-
	Panggu	3	12	3	-	-	-	1	4	-	-	23	6%
	Receipt	3	15	1	-	-	-	-	3	-	-	22	5%
1979	Total	99	378	46	5	8	31	29	23	-	-	619	-
	Panggu	2	9	6	-	-	-	2	4	-	-	23	4%
	Receipt	2	14	1	-	-	-	-	2	-	-	19	3%

[1] Small prawn trawlers were first employed in Kedah/Perlis in 1967.

TABLE 3.3 : NUMBER OF OPERATING PULAU KETAM TRAWLERS AND BOAT-YEARS OF PKT PANGGU [1] DATA

OBTAINED EACH YEAR FROM 1965 THROUGH 1979 CATEGORISED BY HORSEPOWER CLASS

Year	Sample Type	0-19	20-39	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	Total	% of Total
1965	Total	-	1	-	-	1	1	-	-	-	-	3	-
	Panggu	-	-	-	-	-	-	-	-	-	-	-	-
1966	Total	-	1	-	1	1	1	-	-	-	-	4	-
	Panggu	-	-	-	-	-	-	-	-	-	-	-	-
1967	Total	-	1	-	-	1	1	-	1	-	-	4	-
	Panggu	-	-	-	-	-	-	-	-	-	-	-	-
1968	Total	-	1	2	1	2	1	-	1	-	-	8	-
	Panggu	-	-	-	-	-	-	-	-	-	-	-	-
1969	Total	-	13	5	4	2	4	2	3	1	-	34	-
	Panggu	-	-	-	-	-	-	-	-	-	-	-	-
1970	Total	-	15	7	7	2	5	2	4	1	-	43	-
	Panggu	-	-	-	-	-	-	-	-	-	-	-	-
1971	Total	-	16	8	11	3	6	2	6	1	-	53	-
	Panggu	-	-	-	-	-	-	-	-	-	-	-	-
1972	Total	-	22	8	13	3	5	4	11	1	-	67	-
	Panggu	-	-	-	-	-	1	-	1	-	-	2	3%
1973	Total	-	22	8	13	3	6	4	14	3	-	73	-
	Panggu	-	-	-	-	-	-	-	-	-	-	-	-
1974	Total	-	22	8	13	3	6	4	17	6	-	79	-
	Panggu	-	-	-	-	-	-	-	-	-	-	-	-
1975	Total	-	23	9	13	3	8	7	20	15	-	98	-
	Panggu	-	3	1	-	-	1	1	1	-	-	7	9%
1976	Total	-	22	9	12	3	10	7	27	22	2	114	-
	Panggu	-	11	1	5	-	7	4	14	14	1	57	50%
1977	Total	-	22	9	12	3	10	8	27	22	5	118	-
	Panggu	-	11	-	6	1	5	7	18	17	5	70	59%
1978	Total	-	21	9	12	2	12	8	31	21	9	125	-
	Panggu	-	10	1	4	-	7	7	20	18	7	74	59%
1979	Total	-	21	8	13	2	13	9	33	21	11	131	-
	Panggu	-	7	-	4	1	5	6	9	11	4	47	36%

[1] There is no trip receipt data for Pulau Ketam trawlers.

TABLE 3.4 : NUMBER OF OPERATING FISH TRAWLERS AND BOAT-YEARS OF FT PANGGU AND TRIP RECEIPT DATA OBTAINED EACH YEAR FROM 1965 THROUGH 1979 CATEGORISED BY HORSEPOWER CLASS

Year	Sample Type	100-119	120-139	140-159	160-179	180-199	Total	% of Total
1965[1]	Total	–	12	5	–	–	17	–
	Panggu	–	–	–	–	–	–	–
	Receipt	–	–	–	–	–	–	–
1966	Total	2	15	8	–	–	25	–
	Panggu	–	–	–	–	–	–	–
	Receipt	–	–	–	–	–	–	–
1967	Total	18	32	19	1	–	70	–
	Panggu	–	–	–	–	–	–	–
	Receipt	–	–	–	–	–	–	–
1968	Total	20	42	25	1	–	88	–
	Panggu	–	–	–	–	–	–	–
	Receipt	–	–	–	–	–	–	–
1969	Total	21	61	62	2	–	146	–
	Panggu	2	2	5	–	–	9	6%
	Receipt	1	7	6	–	–	14	11%
1970	Total	18	63	79	7	–	167	–
	Panggu	1	1	9	–	–	11	7%
	Receipt	–	–	–	–	–	–	–
1971	Total	10	60	73	47	2	192	–
	Panggu	1	1	10	3	–	15	8%
	Receipt	–	–	–	–	–	–	–
1972	Total	8	48	56	63	3	178	–
	Panggu	1	1	10	5	–	17	10%
	Receipt	–	–	–	–	–	–	–
1973	Total	3	49	59	68	10	189	–
	Panggu	1	1	9	8	–	20	10%
	Receipt	–	2	1	5	–	8	4%
1974	Total	–	46	89	82	12	229	–
	Panggu	–	–	6	14	2	23	10%
	Receipt	–	2	5	8	–	15	7%
1975	Total	–	43	70	77	23	213	–
	Panggu	–	2	4	19	8	33	15%
	Receipt	–	2	6	8	5	21	9%
1976	Total	–	32	31	82	50	195	–
	Panggu	–	–	4	17	20	41	21%
	Receipt	–	–	2	12	7	21	11%
1977	Total	–	36	11	69	101	217	–
	Panggu	–	–	3	8	20	31	14%
	Receipt	–	–	1	12	7	20	9%
1978	Total	–	32	6	59	137	234	–
	Panggu	–	–	3	6	22	31	13%
	Receipt	–	–	1	10	7	18	8%
1979	Total	–	26	2	45	161	234	–
	Panggu	–	–	1	4	19	24	10%
	Receipt	–	–	–	5	15	20	9%

3.14 Product and Labour Market Surveys

Beginning in May 1979 we carried out two sets of surveys. One set was concerned with basic descriptive data on the market agents, which in the case of the fish trawlers included the trawl owners, and their functions. The other set concerned the biographical and work history of the trawl crews.

3.14.1 Market agent survey

The market agent survey set used four questionnaires (see Appendix A). The first questionnaire (QUES 01) concerned with the biographical and work history of the market agents, concentrated on various aspects of their participation in the fishing industry in general and in trawling in particular. The second questionnaire (QUES 04) dealt with the number, types and work history of fishing vessels owned by the market agents, and the type and diversity of their fishing and non-fishing business activities. The third questionnaire (QUES 08) elicited information on the availability, use and cost of short-term credit (i.e.credit in kind or cash for covering the running expenses of the fishing enterprise). The final questionnaire of this set (QUES 10) dealt with the marketing activity of the agent, more specifically with the marketed volume, market channels used and the hierarchy of decisions governing their use.

Before the survey was carried out, the population of FT owners and firms had to be established. The number of SPT and PKT market agents had been determined from the 1978 trawl licence records by aggregating the fish trawlers by the identity code number of the registered owner. Many individuals, partnerships and families were known to collectively own and manage a fleet of fish trawlers but register individual vessels severally in the names of the owners in order to hide the scale of the firm. Since the objective was to obtain a description of the FT firms, the fleet had to be aggregated by firms and this was done with the assistance of the 17 FT examiners. Each FT firm operates from an address which is consistently used in the licence forms of all their vessels irrespective of whose name they were in. The number of the FT firms was subsequently amended in the light of the survey conducted and the interviews held with all FT firms.

From the list of FT firms 40 were selected at random. All questionnaires were satisfactorily completed in the cases of 36 of the firms. Four additional FT firms were subsequently interviewed and these provided either panggu or trip receipt data. The total survey sample size was thus 40 firms out of a total of 84 firms or 49% of the total. (The total of 84 firms is the final estimate and includes all changes found necessary subsequent to the market agent survey and discussions with FT firms.)

It was possible to interview the small number of SPT and PKT market agents in Kuala Kedah. Of the 11 Chinese and 3 Malay SPT market agents, 7 of the former and 2 of the latter provided accurate information. The 9 PKT market agents who assisted in the examination of the Annual Boatlists (out of a total of 11 PKT market agents) did likewise. The market agents who declined to give satisfactory information were basically more reluctant to divulge "proprietary information" and their response could not be attributed to any significant difference in their firms.

3.14.2 Crew survey

The same questionnaire for the market agent survey (QUES 01, in Appendix A) was used in the survey on the biographical and work history of trawler crews. The main emphasis of the survey was on the experience, skills, opportunities and rewards of the trawler workforce from the ports studied. 325 trawl crew members, 250 in Kuala Kedah and 75 in Tanjong Dawai, were interviewed. Of these, 30 interviews had to be rejected because of incomplete or inaccurate information. The final sample size was 12% of the 2,562 men estimated by the Fisheries Division to be employed full-time on licensed trawlers in Kedah/Perlis in 1978 (see Table 3.5). The 234 trawler crew members satisfactorily interviewed in Kuala Kedah are nearly 35% of this port's corresponding labour force.

In Kuala Kedah the crew interviewed was equally divided between prawn and FT crews. Naturally only FT crews were interviewed in Tanjong Dawai. There were no statistics on the distribution of the total trawler labour force among the several trawl types. On the bases of the trawler population composition in Kuala Kedah (70% of prawn and 30% of fish trawlers) and their respective average crew sizes (of 3 and 6 men), it was assumed that the port's trawler labour force was equally divided between fish and prawn trawlers, and thus sampled accordingly. Prawn trawlers probably employed a fractionally larger proportion of the labour force (see Table 3.5). However, as the main focus of the study is the fish trawlers, a slightly larger sample size of fish trawlers was thought justified. The 125 prawn crew members surveyed were composed of 69 and 64 SPT and PKT respectively. More attention was given to PKT crews for a more

TABLE 3.5 : CREW SURVEY SAMPLE

	Total[1] Ked/Per	K.K.[1]	T.Dawai [1]	Trawl Type in Kuala Kedah SPT	PKT	FT
1. Initial Sample	325	250	75	75	75	100
2. Total Sample	295	230	65	69	64	97
3. Total Fishing Labour Force	2562	1819	188	1215 [2]	438 [3]	1040 [4]
4. (2) as a % of (3)	12%	13%	35%	6%	15%	9%

[1] Source: Annual Fisheries Statistics, 1979.

[2] Estimated number of persons employed on licensed and unlicensed SPT vessels in Kedah/Perlis in 1978. This estimate was obtained by multiplying the average SPT crew of 3 persons by the number of SPT vessels operating in Kedah/Perlis, Table 3.2.

[3] Estimated number of persons employed on licensed and unlicensed PKT vessels in Kuala Kedah in 1978. This estimate was obtained by assuming the average crew size of PKT vessels to be 3.5 persons and by multiplying this figure by the number of PKT operating off Kedah/Perlis in 1978, Table 3.3.

[4] Estimated number of men employed in FT in Kuala Kedah in 1978. An average crew size of 5.5 was assumed and multiplied by the number of FT operating from Kuala Kedah in 1978, Table 3.4.

thorough description of this trawl type because it was considered as the type of prawn trawler to which FT owners would most likely switch.

Upon returning from sea, the trawlers were found to be spatially and temporarily concentrated by trawl type. This permitted the sample to be stratified by trawl type and led to economies of size in interviews. The prawn trawlers returned from a trip between 7.00 a.m. and 9.30 a.m. The SPT vessels unloaded at one of the 16 jetties owned by the SPT market agents or assemblers and all PKT vessels unloaded at the Majuikan jetty in Kuala Kedah. The crews of these trawl types were interviewed after they finished unloading and before the trawler left the jetty for its mooring. The FT vessels returned from sea between 6.00 p.m. and 7.30 p.m. and docked and unloaded at one of the 65 jetties in Kuala Kedah or at the single dock in Tanjong Dawai. The FT crew members were interviewed after they had loaded and packaged the catch and before they dispersed.

The respondents were not selected at random but were selected by interviewing all available crew members on or near the jetty during a visit. Particular attention was paid to sampling captains because their shore responsibilities often made them less available. All SPT and PKT jetties were visited at least twice during the survey. In view of the large number of FT jetties and since a major objective of the crew survey was to supplement the panggu data and the market agent survey, visits were made only to the FT jetties where the respondents to these surveys moored their vessels.

3.15 Panggu and Trip Receipt Data

From early July through the end of September 1979, access to all panggu and/or trip receipt data available was requested from all SPT and PKT market agents and FT firms. The extreme reluctance of these parties to even discuss the existence of such data, let alone grant access to them, necessitated a series of unstructured exploratory discussions on various technical, organisational and decision-making aspects of the firm [8]. Those discussions served as an introduction to and a means of gaining the confidence of the respondents, and also facilitated the checking and augmenting of information collected in other surveys.

3.16 SPT Panggu and Trip Receipt Data

Panggu and trip receipt records for SPT vessels were scarce. The SPT market agents were in general co-operative but very few had records for a particular trawler for more than a few months. This was because they only kept these records for clients who sold them their

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[8] The major points covered during these discussions were:

1. the organization of the firms with particular concern given to the availability of panggu and trip receipt records;

2. the historical trends and present state of the technological, temporal, spatial and managerial component of fishing effort;

3. changes in marketing practices and channels since 1965;

4. the decision-making process concerning :

(a) the rate of fishing effort per time period,

(b) choice of trawl type,

(c) choice of trawl size and scale of firm, and

(d) entry to and exit from the trawl fishery.

entire catch in exchange for loans and services and the majority of the SPT owners at least do not maintain fully tied relationships with any one market agent for more than a few months. Regrettably, as a result of the transient nature of SPT owner-market agent ties, only 3 SPT market agents in Kuala Kedah had annual panggu and/or trip receipt records. Of these, 2 provided access to them. The number of boat-years of SPT panggu and trip receipt data thus obtained and classified by horsepower class and year is given in Table 3.2. Two boat-years of panggu data obtained from the Peace Corps study [1970, [Vols. 1 & 2, Sec.1, pp.1-32] were also included in Table 3.2.

The SPT panggu data and, to a lesser extent, the trip receipt data are adequate for the identification and quantification of competition between the SPT and FT fleets in view of the total sample size and its distribution over horsepower classes. From 1975 to 1979, the panggu sample is between 5% to 10% of the SPT population. However, before 1975, the panggu data is very limited, representing less than 2% of the SPT population. The trip receipt sample follows the pattern of the panggu data with fewer boat-years in the later years than in the earlier years. With the exception of the 100-119 horsepower class, the panggu and trip receipt sample distribution by horsepower class is approximately proportionate to the SPT populations for 1975 to 1979. Prior to 1975. the small sample size precludes even visual comparison of the sample and population distributions.

When assessing the utility of the SPT panggu and trip receipt samples, the most important task was to ascertain the existence, direction and/or amount of bias. Since the trawlers sampled were not, and indeed could not be, selected at random, but were selected on the basis of the durability of market agent ties, the initial hypothesis must be that potential for bias does exist. Quantitative identification or measurement of any bias is not possible in the absence of alternative information. Nevertheless, a description of SPT owner-market agent ties should indicate any significant differences between the sampled trawlers and the SPT population and hence the direction, if any, of bias.

The SPT market agents attempt to maximise profits by adjusting the prices, loans and other services offered to the trawl owners. The composition of the price and loan/services package offered to an SPT owner is determined by the market agent's expectations of the future profitability of the trawler and the probability of the owner switching over to another market agent before or after loans are repaid. There are three loan/service packages offered by the market agents in Kuala Kedah.

Under the first package, the market agents purchase the catch or a portion thereof from the trawl owners at a competitive price without providing any loan or service. This package is offered to SPT owners who either do not need the loans and services or who are regarded as unlikely to repay the loans because of poor catches or because they are likely to sell their catch elsewhere. Thus the market agent acts simply as an assembler.

Under the second package, the market agent provides limited loans and services to the trawl owners. The market agent attempts to recoup costs and maximise profits in a short period of time, usually a few months, by offering a relatively low price to the owner. There is a flexible floor price prevailing in Kuala Kedah, below which the market agent will not go for fear of inducing the trawl owner to sell his catch elsewhere. The prices offered under this package are, nonetheless the lowest of the three packages. The competitiveness of the SPT marketing system together with the low prices offered under this package is the major reason for the instability of marketing arrangements and the absence of records.

Under the third package, the market agent provides loans, without any specific restriction, and the full range of services in conjunction with a set of prices intermediate between the prices under the first two packages. The market agent by so doing maximises profit with expectations of a long stable relationship.

The SPT market agents seldom offer a price and loan/services package of the third type to Malay, younger Chinese and the most productive SPT owners. The Malay SPT owners are restricted to the first two packages because the Chinese market agents rate their probability of non-repayment as high. Likewise, the three Malay market agents are reluctant to offer the third package to Malay owners and in any event they do not have sufficient funds to do so. The younger Chinese are said to have a high preference for the first package because additional funds earned from package one, when catches are good, can at times more than cover the lean periods. In the light of the discernible preference of the younger Chinese SPT owners for package one, market agents only offer the second package to them. The most productive fishermen simply do not desire or need the loans or services of the market agents and confine themselves to package one.

The SPT owners from whom the <u>panggu</u> and trip receipt data were obtained, were the older Chinese from Kuala Kedah who have been owner-operators of smaller fishing vessels for their entire lives and had done so under either a fully tied or first package system. Those accustomed to the fully tied system, are more risk adverse than the younger Chinese SPT owners, or are less able to carry out the shore functions and consequently prefer package three. The sample trawlers were neither the most nor least productive or profitable small prawn trawlers in Kuala Kedah. For if they were amongst the most profitable, they would not need or want package three nor would they be indebted to the market agents from 1975 to 1978 to an average sum of $2,957. The average annual debt had increased from $2,364 in 1975 to $3,288 in 1979. The sample vessels were not amongst the least productive or profitable because the market agents would not offer the third package to an unproductive boat and the prices under the third package were higher than those under the second package. Moreover, the sample vessels were not sold frequently as was the fate of unproductive trawlers. Thus statistically unsatisfactory though the sample may be, any bias is probably not serious and productivity and profitability of the sample trawlers are somewhat average.

3.17 PKT Panggu and Trip Receipt Data

Panggu records from 1975 onwards were more available and accessible for *Pulau Ketam* trawlers than for the other trawl types. The relationships between the PKT owners and market agents were more stable than those between the small prawn trawlers and the agents. As all PKT owners operated under the third price and loan/services package, the PKT market agents had records for a large number of trawlers for a number of years. Complete panggu records were obtained from 9 of the 11 PKT market agents and the number of boat-years of PKT panggu data obtained is listed in Table 3.3 by horsepower class and year, along with the corresponding population of Pulau Ketam trawlers. The total sample size and the sample size per horsepower class from 1976 to 1979 is quite large, between 36% and 59% of the total PKT population. The total sample size decreases to 9% in 1975, with a corresponding decrease in and scattering of the sample distribution across horsepower classes. Panggu records were not available for PKT vessels for the years before 1975 except for two boat-years in 1972. Unfortunately, PKT market agents do not retain trip receipt records for Pulau Ketam trawlers.

The type of client, marketing ties, trawlers or fishing effort of the PKT market agents who availed this study of their panggu records, did not differ from those of the unco-operative market agents. Personality differences accounted for their responses to the study. A comprehensive description of the organization and client composition of all PKT market agent firms was obtained through the market agent surveys and the unstructured discussions. No difference was discerned between the co-operative and the unco-operative PKT market agents that would lead to a bias in estimates derived from the sample data.

3.18 FT Panggu and Trip Receipt Data

The unstructured discussions with all FT firms enabled the accurate identification of the firms which maintained panggu and trip receipt records. Of the 84 FT firms, 58 had complete panggu records and 38 had complete trip receipt records for 1978 and 1977 representing 70% and 46% respectively of the total firm population (see Table 3.6). The initial panggu and trip receipt records provided for this study did not show income from marketing. They were thus incomplete. These records were, however, kept by the FT owners for two main reasons. First all kongsis or multiple-owner-firms kept records so as to keep the several owners informed of business decisions and results. Second, the Malaysian federal income tax laws require all businesses to keep records of their costs and earnings for at least 4 years. The income tax department is authorised to make its own estimate of the taxable income of any enterprise without satisfactory records, and to impose fines on firms found to have under-reported their taxes. Since the panggu and trip receipt records do not include income earned from marketing, the FT firms keep these records for the tax department as evidence of total costs and earnings. In practice, this regulation is considerably less effectively enforced in the cases of enterprises such as hawkers, farmers and small owner-operator fishermen, but the larger the enterprise, the greater the risk of its enforcement. The FT owners who did not maintain records on an annual basis were accordingly found to be small individually-owned firms with less than two trawlers on the average and where the owner was also the operator, or who have in any event started out as one. A result of this is that small scale owner-operator or fishermen-owned FT firms are under-represented in the existing stock of FT panggu and trip receipt records.

Eighteen FT firms were subsequently persuaded to disclose their complete sets of panggu records . This represented 31% of all FT firms

TABLE 3.6 : TOTAL POPULATION OF FT FIRMS WITH PANGGU RECORDS AND FT FIRMS WITH TRIP RECEIPT RECORDS, AND THE NUMBER AND PERCENTAGE OF FT FIRMS THAT PROVIDED BOTH RECORDS IN 1978

	1978	% (a) of Tot.	% (b) of (a)
1. Total No. of FT Firms	84	-	-
2. Panggu Data: No. of FT Firms			
a) with Panggu records	59	70	31
b) that provided Panggu rec.	18		
3. Trip Receipt Data: No. of FT Firms			
a) with trip receipt rec.	38	46	26
b) that provided trip receipt rec.	10		

Source: Field work, 1979.

that had panggu records and 21% of the entire FT firm population (see Table 3.6) [9]. However, only 10 FT firms or 26% of all FT firms with such records or 12% of the FT firm population [10] provided access to their trip receipt records. The total number and distribution by horsepower class of boat-years of both panggu and trip receipt data for 1969 to 1979 is given in Table 3.4. The total panggu sample varies in a parabolic manner over this period from 6% in 1969 to 10% in 1979. The distribution of the panggu sample amongst horsepower classes represents adequately each horsepower class but under-represents the two lower horsepower classes proportionately

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[9] We were allowed access to all panggu records retained by the FT firms who made such records available, including panggus for trawlers no longer owned by the firm. Panggu records for a particular trawler in a particular year were used only if all panggus for that year were available.

[10] We were also allowed access to all trip receipt records retained by the providing FT firms, including records for trawlers no longer owned by the firm. Since our period of analysis was a month for trip receipt data as opposed to a year for the panggu data, we used trip receipt records for a given boat and month only if all trips undertaken were covered. Thus a number of boat-years of trip receipt records collected did not contain all the months during which the trawler operated.

population distribution. The trip receipt sample (4% in 1973 and 7% in 1979 of total operating fish trawlers) is smaller than that of the panggu sample and trip receipt records were also not available for 1970 to 1972. The pattern of distribution of the trip receipt sample amongst horsepower classes is similar to the panggu sample but has fewer observations.

Table 3.4 also includes eight boat-years of 1969 panggu data from the Peace Corps study [1970, Vol.2, Sec.1, pp.1-32 and computer print out of all raw data collected in that study] and 14 boat-years of 1969 trip receipt data from co-operative records. The Peace Corps Study is a cost and earning investigation of 10 trawlers from Kuala Kedah; two small prawn trawlers and eight fish trawlers. The sampled trawlers, as those used in this study, were not selected at random but were selected according to the co-operation of their owners. The 1969 co-operative trip receipt data were obtained from a former co-operative officer who managed the first trawl co-operative in Kuala Kedah from 1965 to 1969 and who maintained that the information submitted by these 14 trawlers was correct.

3.19 Adequacy of the FT Panggu and Trip Receipt Data

Since the panggu and trip receipt data could not be selected at random, the next best option was to investigate every FT firm to solicit their records. Under these circumstances the possibility of bias in the resulting sample has to be considered. As with the SPT sample, the existence and /or extent of any bias could not be established for lack of alternative information on the cost and earnings, and catch and effort of the fish trawlers. The survey sets therefore had to be relied on and a qualitative comparison of the sample made with the FT population.

It was noted in the foregoing discussion that the small-size owner operating FT firms were under-represented in the sub-population of FT firms possessing records and that the trawlers in the small horsepower classes were proportionately under-represented in the _panggu_ and trip receipt samples. Nevertheless both types of records were obtained from three owner-operators who owned four trawlers.This was admittedly a very small sample size, but the three owner-operators represented 21% of the 14 owner-operating FT firms in Kuala Kedah and should help mitigate the under-representation of small scale firms. Although the number of boat-years sampled in the larger horsepower classes was disproportionate, records of all horsepower classes were available.

Two factors had to be established with respect to the quality of these samples. One is the motivation for FT owners to disclose their records. The other is the presence, if any, of differences between these firms and their trawlers and their respective counterparts. The findings differ in the cases of the _panggu_ and trip receipt records.

Statistical comparisons with the FT firms interviewed in the market agent survey and impressions gathered in discussions with the FT firms confirmed that the sample of FT firms which supplied _panggu_ data is fairly representative of the FT firm population.

The FT firms sampled in the market agent survey were selected at random, except for four FT firms which were subsequently included in the survey because they provided _panggu_ and/or trip receipt records. In the market agent survey, information on various characteristics of the firms and the firm managers [11], which a priori were thought to be positively correlated with firm and thus trawler "success" were collected. The null hypothesis (H_0), that the sample mean for each of these characteristics of the sample of FT firms included in the market agent survey is equivalent to the corresponding sample mean of the sub-sample of FT firms which provided panggu records is accepted with a 10% confidence level (see Table 3.7). This lends support to the view that the sample of FT firms which provided panggu records were a reasonably representative sample of the FT firm population.

3.20 Panggu Sample

Three discernible reasons explain why FT firms provided complete access to their panggu records. First, many FT firms had already submitted these records to the income tax department. Second, they were convinced after many months of continuous discussions, cajoling and pleading that members of this study were not affiliated with the government or the co-operatives and that the industry was understood from their perspective. Third, some of the FT firms were persuaded by members of the study that management of the trawl fishery was necessary and potentially beneficial to them.

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[11] The four characteristics of the FT firm managers listed in Table 3.7, i.e. age, years of education, years of work as captain, years of work as owner-non-operator, should, as indicators of experience and skill, correlate positively with firm success and thus trawler success. The two characteristics of the firm listed in Table 3.7, i.e. number of trawlers owned and duration of trawler ownership, should indicate respectively the ability of the firm to expand and to survive.

TABLE 3.7 : T-TEST FOR THE EQUALITY OF THE MEANS FOR VARIOUS CHARACTERISTICS OF THE FT FIRM BETWEEN THE MARKET AGENT SURVEY SAMPLE AND THE SUB-SAMPLE OF FT FIRMS WHICH PROVIDED PANGGU, AND THE SUB-SAMPLE OF FT FIRMS WHICH PROVIDED TRIP RECEIPT RECORDS

	No. of Firms	Mean	Std. Deviat.	Std. Error	T-Test T-Value Deg. of Freedom for $H_0:U_a=U_b$	$H_0:U_a=U_c$
1. Age [1] :						
a) total sample [2]	40	45.4	11.987	1.895	0.05 #	0.53 **
b) panggu sample [3]	18	45.2	11.307	2.664	d.f.= 56	d.f.= 48
c) trip receipt sam.	10	43.1	13.237	4.186	(0.964)[4]	(0.601)
2. Education :						
a) total sample	40	6.4	4.229	0.669	0.15 **	-0.62 **
b) panggu sample	18	6.2	4.4	1.037	d.f.= 56	d.f.= 48
c) trip receipt sam.	10	7.4	5.661	1.79	(0.884)	(0.536)
3. Years Wkd. as Cap.:						
a) total sample	40	3.0	5.591	0.884	0.26 **	0.15 **
b) panggu sample	18	2.6	6.051	1.426	d.f.= 56	d.f.= 48
c) trip receipt sam.	10	2.7	3.917	1.239	(0.789)	(0.884)
4. Years Wkd. as Owner (non-operator)						
a) total sample	40	9.0	5.418	0.857	-0.88 **	-0.56 **
b) panggu sample	18	10.4	4.984	1.175	d.f.= 56	d.f.= 48
c) trip receipt sam.	10	8.0	5.558	1.758	(0.385)	(0.579)
5. Ownership of trawler (no. of years)						
a) total sample	14	12.6	5.453	0.862	-0.47 **	-0.64 **
b) panggu sample	18	13.3	5.750	1.355	d.f.= 56	d.f.= 48
c) trip receipt sam.	10	11.4	4.477	1.416	(0.643)	(0.524)
6. No. of Fish Trawlers Owned						
a) total sample	40	3.1	2.373	0.375	0.16 **	0
b) panggu sample	18	3.0	1.534	0.362	d.f.= 56	d.f.=48
c) trip receipt sam	10	3.1	0.876	0.277	(0.871)	(1.00)

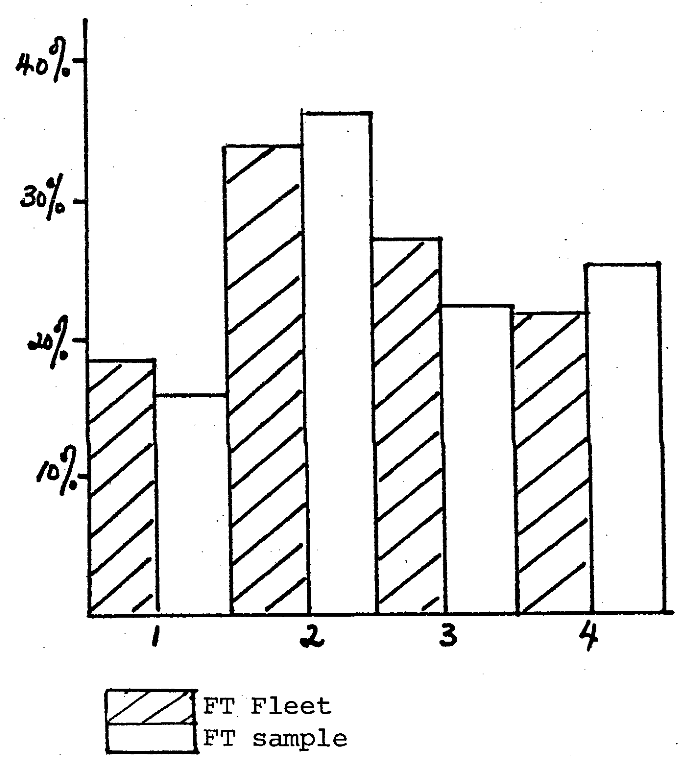
[1] Characteristics refer to the manager or the senior member of the FT firm.
[2] Panggu sample is the sub-sample of the interviews under the market agent survey with the FT firms that provided panggu records.
[3] Trip receipt sample is the sub-sample of interviews under the market agent survey with the FT firms that provided trip receipts.
[4] This is the 2-tail probability for given T-value and degrees of freedom (d.f.)
** Null hypothesis accepted with 10% confidence level.
# Null hypothesis accepted with 15% confidence level.

Upon the conclusion of unstructured discussions with an FT firm, each fish trawler owned by the firm was immediately graded into four categories of profitability with the help of the FT examiners : (1) just covering running costs, (2) covering running costs but not costs of repair and maintenance, (3) just covering repair and maintenance costs, and (4) more than covering all costs. This somewhat rough grading of the FT fleet provided a guide to the direction of solicitations of FT firms. Figure 3.1 illustrates the comparative distribution amongst the four grades of the 208 fish trawlers stationed in Kuala Kedah and the sample of fish trawlers from Kuala Kedah for which records were obtained. In all categories, the population and sample shares are within five percentage points. Directed by the grading system, significantly more effort was applied towards owners of vessels in grades 3 and 4 who were in general more reluctant to make available these records.

3.21 Trip Receipt Records

Trip receipts were less available and accessible than panggu records. The FT firms often did not retain trip receipt records after a few panggu for three reasons. First, the trip receipts are kept by the owner in order to provide the captain and crew with itemised trip records. After a few panggu the crew rarely requested the records which were then often disposed of. Second, the tax department is often satisfied with the more aggregate panggu records. Third, when the wholesale market price is substituted for the ex-vessel price, the trip receipts can be used to estimate the total revenue inclusive of share and marketing income; information which the FT firms are reluctant to divulge.

FIGURE 3.1: DISTRIBUTION OF FT FLEET AND FT PANGGU SAMPLE BY CATEGORIES OF "SUCCESS"



Categories:

1. Trawlers which barely cover trip costs.
2. Trawlers which cover trip costs but not repair and maintenance costs.
3. Trawlers which just cover repair and maintenance expenses.
4. Trawlers which more than cover repair and maintenance expenses.

Trip receipt records from FT firms were obtained usually when the assistance of an educated member of the firm or family (usually the son or daughter of the firm manager) could be solicited. The relevance and justification of this research were more easily explained to these individuals who were frequently active members of the FT firm than to the average FT firm manager. This was true too of requests for data.

The sample of FT firms from which trip receipt records were obtained, despite its small sample size, appears to be a reasonably representative sample of the FT firm population. The null hypothesis is that the sample means are equal for each of the key productively related characteristics between the sample of all FT firms included in the market agent survey and the sub-sample of FT firms which provided trip receipt records at the 10% confidence level (see Table 3.7).

The sample of trawlers from which trip receipt records were obtained, also appears to be representative of the fish trawler population. Table 3.8 compares the mean values of the primary determinants of trawler profitability from the sample of all fish trawlers for which panggu data were obtained and the sample of fish trawlers for which panggu and trip receipt data were obtained. The null hypothesis that the mean of the samples are equal for each variable is supported at a 10% confidence level.

3.22 Vessel Survey Set

Towards the latter part of the fieldwork a survey was conducted of all trawlers for which panggu and/or trip receipt data was

TABLE 3.8 : COMPARISON OF THE MEANS OF THE MAJOR VARIABLES OF TRAWLER PROFITABILITY BETWEEN THE SAMPLE OF FISH TRAWLERS FOR WHICH PANGGU DATA IS AVAILABLE AND THE SAMPLE OF FISH TRAWLERS FOR WHICH TRIP RECEIPT AND PANGGU DATA ARE AVAILABLE IN 1978

	No. of Trawlers	Mean	Std. Deviat.	Std. Error	T-Test T-Value Deg.of Free. $H_0:U_a = U_b$
1. Total Revenue/day at sea					
a) FT panggu sample	24 [1]	340	45.784	9.346	-0.31 **
b) FT trip receipt sam.	8 [2]	346	42.317	14.961	d.f.= 30 (0.755) [3]
2. Total Run. Costs/day at sea					
a) FT panggu sample	24	210	28.011	5.718	-0.07 **
b) FT trip receipt sam.	8	210.8	20.491	7.245	d.f.= 30 (0.946)
3. Crew and Owner Share					
a) FT panggu sample	24	61.61	12.711	2.595	-1.46 **
b) FT trip receipt sam.	8	69.60	15.576	5.507	d.f.= 30 (0.156)
4. Days at Sea/month					
a) FT panggu sample	24	20.8	1.669	0.590	d.f.= 30 (0.219)

[1] All vessels with engines of 175 horsepower and above are included in the samples.
[2] Not all fish trawlers for which trip receipt records were available were included in the samples.
[3] The 2-tail probability for the given T-value and degrees of freedom.
** Null hypothesis accepted with 10% confidence level.

obtained. The survey contained a set of three questionnaires (see Appendix A). The first questionnaire (QUES 05) dealt with the characteristics, purchase price, life and salvage value of the major capital items, i.e. hull, engine, gearbox and net. An estimate of the 1978 repair and maintenance costs was also solicited. The second questionnaire (QUES 07) focused on the use, sources and cost of major capital equipment loans. The final questionnaire (QUES 11) solicited information on the various dimensions of fishing effort as well as size and composition.

CHAPTER 4

ECONOMIC THEORY OF FISHING

4.1 Scope

There are two basic features of commercial fisheries, which differentiate the economic theory of fishing from the standard theory of the manufacturing firm and industry. These are the renewable capacity of the resources and the absence of property rights. A fish stock is renewable in the sense that through the biological processes of birth, growth and mortality, it has a regenerative capacity. The regenerative process of a fish stock, exhibits a stock-flow relationship. The size of the fish stock (X_t) in time period t, is determined by the size of the fish stock in the previous time period (X_{t-1}) and net result of growth and mortality upon (X_{t-1}). Growth is composed of both recruitment of new individual fish via birth or emigration and the increase in weight of the individuals making up (X_{t-1}). Mortality is composed of deaths due to natural causes, and if there is a fishery, the catch which man takes. The renewable capacity of a fish stock in response to fishing mortality, acts as a constraint to the sustainable operation of a fishery. Thus the economic theory concerning fisheries must combine the theory of the firm with that of the dynamics of fish populations to produce a bionomic theory.

Most, if not all, non-sessel marine fishery resources are open access. Because of the fugitive nature of the resource, individual property rights cannot be established and the resource is therefore available to all and owned by none. A firm, exploiting an open access resource such as a fish stock will, because of the absence of market price to individual firms, treat the resource as a free good. This type of market failure (as used by Bator, 1958) commonly results in four distinct types of externalities to the individual firms exploiting a fish stock [Smith, 1969,p.181]:

1. Stock externalities result when the cost of a fishing unit's catch decreases as the fish population increases.
2. Growth externalities occur if the gear employed directly affects not only the private costs and revenues of the fishing unit but also the growth behaviour of the fish population.
3. Crowding externalities arise when the vessels are sufficiently congested geographically to result in increased costs.
4. Ecological externalities result when the ecological structure structure of the marine environment is altered as a result of fishing activity causing changes in the growth and natural mortality parameters of the fish stock.

The suboptimal allocation of resources within a fishery resulting from an assortment of the above types of depletable or private externalities, [see Baumol and Oates, 1975, p.19 for definition] necessitates that the economic theory of fishing be able to describe the existence of these externalities, and produce guidelines for improving the resultant misallocation of resources.

4.2 Population Dynamics

Models of fish populations developed by biologists are the basis upon which the bionomic theories of fishing are developed. Therefore it is necessary from the outset to describe the theoretical foundations of these models and to discuss the mechanics of the widely used surplus production model.

Numerous mathematical models have been developed to estimate and predict the dynamic relationship between size of a fish stock and fishing effort [see Ricker, 1975, pp.24-25]. The most widely used are the dynamic pool models such as Beverton and Holt (1957), and Ricker (1958), and the surplus production models of Schaeffer (1954, 1957) and its variants, Gulland (1961), Fox (1970) and Pella and Tomlinson (1969).

Both categories of population dynamic models attempt to estimate the amount of sustainable yield or catch that can be taken from a given stock size by a given number and type of fishing vessels. The dynamic pool models use information on the rate of growth, recruitment, natural mortality and age distribution of the fish stock in the modelling process. The surplus production model attempts to relate the potential sustainable yield of a stock directly to its abundance, without explicit consideration of individual components of growth and mortality.

The surplus production models have been employed in the vast majority of analytical and empirical economic studies. Its dominance is due mainly to its analytical simplicity and low information demand, rather than yielding statistically superior results or possessing more robust descriptive powers.

4.3 Surplus Production Models

The surplus production model is based upon the reasonable postulate that at low levels of abundance, where food and space are plentiful and fecundity high, due to low average age, a fish stock will grow at or near an exponential rate. As stock abundance increases over time, food and space gradually becomes limiting and fecundity decreases with the aging of the stock resulting in downward compensational adjustments in the net growth rate of the fish stock. Under constant environmental conditions, a fish stock, in the absence of fishing, will eventually reach and remain at a level of abundance, which represents the maximum carrying capacity of the environment. This is where growth equals natural mortality. If the level of abundance is reduced below its maximum level, due to fishing for instance, the growth rate will increase in a compensatory manner. The fish stock will eventually reach an equilibrium level of abundance where growth equals both natural and fishing mortality, thus producing a sustainable yield that, ceteris paribus, can be maintained in perpetuity.

Graham (1935) was probably the first to develop a model which expressed the theory of surplus production in the form of a logistic curve. Schaeffer (1954) subsequently introduced a method based upon the logistic curve, through which catch and effort data from commercial fisheries could be used to estimate the value of the sustainable yield.

The change in the biomass of a single species fish population at any point in time can be given:

$$(1) \quad dX/dt = \dot{x} = X_t(g(X_t)) + M_t - F(X_t) + V\,X_t$$

where

X_t = fish stock biomass

$g(X_t)$ = net natural growth rate, including recruitment, rate of growth and natural mortality

M_t = net migration rate

F = fishing mortality rate

V = normally distributed disturbance term.

This specification makes the rather strong assumption that the variables as specified are independent thus effectively ruling out the consideration of growth externalities.

The Schaeffer model expresses the above relationship as:

(2) $\dot{x} = B(X_t) - F(X_t) + V(X_t)$

where $B(X_t) = X_t(g(X_t)) = X_t r(K-X_t)$

K = maximum level of biomass governed by the carrying capacity of the environment, that is $\lim_{t \to \infty} X_t = K$, if F = 0

r = intrinsic growth rate

$M_t = 0$

and $B(0) = B(K) = 0$; $B(X_t) > 0$, $B''(X_t) < 0$ for $0 < X_t < K$

As stated above, when the fishing mortality or effective fishing effort is held constant, $\bar{F}$, population will eventually reach a steady-state level of biomass where $\dot{x} = 0$, at which point

(3) $V_i X_t + B(X_t) = F(X_t) = h_t$

where h_t = rate of harvest or catch.

Assuming that F can be approximated by q.E = F, where

q = catchability coefficient, and

E = fishing effort

we have

(4) $h_t = qEX_t$.

Equation 3 can be restated as:

(5) $h_t = qEX_t = X_t r(K-X_t) + VX_t$

solving for X,

(5a) $X_t = K - Eq/r + V/r$

From equation 4, catch per unit effort (U_e) is assumed to be proportional to the biomass of the fish stock, that is

(6) $U_e = {}^{h}t/E = qX_t$

On the assumption of proportionality and using equation 5a, we can express steady-state population biomass and sustainable catch rate respectively as functions of fishing effort:

(7) $U_e = {}^{h}t/E = (K - qE/r + V/r)q$

where $dU_e/dE < 0$, $dU_e/dK > 0$, $dU_e/dr > 0$

(8) $h_t = KE - qE^2/r + VE/r$

where $dh_t/dK > 0$, $dh_t/dr > 0$, $dh_t/dE \gtreqless 0$

Equation 7 can be estimated by ordinary least squares with annual data from commercial fisheries.

The catch equation (equation 4) used in the surplus production model is a linear, short run production function. Using equation 4 with commercial fishery statistics which can be adjusted to produce instrumental variables (U and E) proportional to stock abundance and fishing mortality, the sustainable yield can be established. The following outlines the assumptions and procedure used in adjusting commercial fisheries statistics and the manner in which complications are handled.

For a single species fish stock homogeneously distributed over a fixed area, $\bar{A}$, the rate of catch, h, from the stock is equal to the product of the rate of fishing F and the level of abundance X_t. That is

(9a) $h_t = FX_t$

and

(9b) $h_t/F = X_t$

The rate of fishing mortality, F, unlike the rate of harvest or catch, is not directly observable and therefore must be estimated from characteristics of the fishing units and their operation. A s outlined in Ricker [1975, pp.18-25] the usual procedure is to assume that F is equal to the product of the catchability coefficient q and fishing effort E, as stated in equation 4. Where q is a measure of the vulnerability of the fish stock to the fishing unit, and E is an instrumental variable representing the physical, temporal and spatial dimensions of the production process.

Schaeffer assumed q to remain constant through time for all values of E and X and thus U, that is equation 7 as linear and equation 8 as parabolic in E. This has been found to be unrealistic under some conditions. Consequently, an alternative model has been developed to consider exponential specification of equation 7 and 8 [Fox, 1970]. Pella and Tomlinson (1969) have developed a generalised surplus production model which specifies the equilibrium harvest and catch per unit effort function as:

(10) $$h_{e} = qE\left(\frac{qE + z}{G}\right)^{1/m-1}$$

and

(11) $$U_e = q\left(\frac{qE + z}{G}\right)^{1/m-1}$$

where

$$G = -r/K$$

$$z = -r.$$

The generalised model allows one to explore a family of production curves by varying m, and choosing the value that gives the best statistical fit. In the Schaeffer model, m = 2, and for the asymptotic or exponential model (Fox model), $m \rightarrow 1$.

The fishing effort of a specific fishing unit can be defined as the product of the fishing power, p, of the vessel and its gear, the nominal fishing effort, or time spent actually fishing (d) and the location or fishing area (a), [Beverton and Holt,1959, pp.171-178], that is:

(12) $t = p \times d \times a$

The fishing power (p) of a specific fishing unit is a measure of the technical efficiency of harvesting at a given area and unit of nominal effort. The usual practice is to use characteristics of the fishing unit available from commercial statistics, such as horsepower, tonnage etc. which are highly correlated to rate of harvest.

Nominal fishing effort (d) is a unit of time, available from statistics concerning the operation of the fishing units, which most precisely represents the time actively fishing where actual fishing time is composed of the time in the fish area searching for fish and the time when the gear is in operation.

If the fish stock is not homogeneously distributed over the total fishing area, but can be stratified into sections that are, the sustainable yield and catch per unit effort (equations 7 and 8) can be estimated for each section separately and added to obtain the total values.

At high levels of stock abundance, the gear of a fishing unit may become saturated to the extent that its fishing power is reduced. This may happen when large catches cause the nets to burst or prevent the capture of fish subsequently encountered. The problem is that if saturation is severe at high levels of U, it is no longer proportional to X. This does not appear to be a critical problem with trawl or purse seine gear in Malaysia. Thus no correcting technique will be discussed.

If there are a number of identical fishing units operating on a fish stock which is again homogeneously distributed over a given area, the total fishing effort (E_t) is simply the sum of the fishing effort of all individual vessels, that is:

$$(13) \quad E_t = \sum_i E_i = \sum_i p_i \cdot d_i$$

Thus the harvest equation is

$$(14)\quad h_t = \sum q\, E_i X = qX \sum E_i = qE_t X \quad .$$

Equation 14 assumes that the harvesting activity of individual vessels are independent, that is, there is no crowding externality. Crowding externalities result when the fish population is concentrated in a number of fish beds causing the fishing units to concentrate their effort on these spots thus affecting each other's catch rate. Ricker (1975, p.22) identifies two major types of bias resulting from the existence of crowding. First the catch per unit effort, U, from a fishing bed may be lower than for the area as a whole. Secondly there may exist physical competition for operating space, resulting in lower operating efficiency or increased costs. The latter category is the externalities relevant to economic analysis and is included in trip costs listed in panggu records. Crowding, of course, may also lead to upward bias in U and E from reduction in search time.

Often a fleet is comprised of a range of fishing unit classes, each having a different catchability coefficient. In such situations, the usual practice is to choose a fishing unit class as a base or standard unit to which the other classes are indexed, expressing E in terms of the standard unit. The general practice [Gulland, 1956] is to estimate the fishing power coefficients p_c for each vessel class (c), in terms of the fishing power of the standard fishing units (s), that is:

$$(15)\quad p_c = U_c/u_s$$

where u, c = 1...s....m, are measured for a given area and unit of nominal effort. Total effort is therefore

$$(16) \quad E_t = \sum_c E_c^s = \sum_c d_c p_c$$

where E_c^s = standardised fishing effort.

Summary

The surplus production model attempts to express the dynamics of fish and other natural populations as a function of the size of population and the amount of productive activity. In the model, the components of growth and natural mortality are lumped into a single parameter precluding explicit consideration of growth and ecological externalities. The harvesting or production process is specified in the population dynamic model as a linear function of a single combination of inputs which are invariant over time. This is done in order to use statistics from commercial fisheries to estimate the rate of fishing mortality and the stock abundance. The linear production function, however, assumes crowding externalities as well as gear saturation are negligible. Thus the surplus production model as specified can only consider the stock externalities from the array of externalities common to open access fisheries.

4.4 Basic Bionomic Model of a Fishery

The following sections present a general model of a single species fishery under open access conditions adapted from Clark (1980). The model is essentially the traditional model of a fishery in that it is unidimensional, autonomous and deterministic. The model is, however, more comprehensive than alternative versions in that it allows greater attention to be placed on the adjustment processes of individual fishing units. In subsequent sections the basic model is modified to examine and compare the 'optimal' rate of fishing under, first, a static, and then a dynamic framework. The result of these analyses are then used to examine the economic efficacy of regulating a fishery via a limited licensing scheme.

It will be assumed that a surplus production model accurately describes the equilibrium yield from a single species stock and that the catch rate of each of the N vessels operating on the stock is given by equation 4, ($h_i = qE_iX$). It will also be assumed that the fishing demand function is perfectly elastic so that each vessel is a price taker, and that each vessel has a convex from above marginal cost curve.

Each vessel then has a net revenue flow given by

$$(17)\quad \P_i = p(qXE_i) - C_i(E_i) \qquad i = 1,2....N$$
$$= \P_i(XE_i)$$

where

p_i = price of fish landed

$\P_i$ = net revenue

$C_i(E_i)$ = total cost of effort.

In the absence of preventive regulations, each vessel will then maximise current net revenue, taking price (p) and fish population levels (X) as given. The amount of effort per vessel is thus given by

$$(18)\quad C_i'(E_i) = pqX \qquad \text{if } pqX > s_i$$

$$E_i = 0 \qquad \text{if } pqX < s_i$$

where s_i denotes the minimum average cost for the ith vessel.

Equation 18 also gives the exit and entry conditions of the fishery, which are:

(19) Vessel i leaves the fishery if $pqX < s_i$

(20) Vessel i enters the fishery if $pqX > s_i$

In order for new vessels to enter the fishery, the expected net revenue over the period of investment must equal the total opportunity cost of invested capital. Decisions governing entry necessarily involve expectations of future earnings which, even in industries without externalities involve considerable uncertainty. A further complication is that given the wide dispersal of net revenue characteristically earned by vessels in a fishery, new entrants often unjustifiably base their entry conditions on the net revenue earned by the most efficient vessels. On the more simple assumption that new vessels base their entry decision on current conditions, the potential new vessel will enter the fishery if

(21) $\text{Max} \;\; \pi_j(X,E_j) > s_j^{'}$

where $s_j^{'}$ represents total opportunity cost of capital for the new vessel.

Assuming $s_j^{'} > 0$, the entry condition for a new vessel is to enter if $pqX > s_j^{'}$ where $s_j^{'} > s_j$.

For each vessel there usually exists a gap between exit and initial entry conditions resulting from the non-malleability of capital. Once vessels are built for a fishery, the opportunity cost of the vessel is often very low, especially, as will be seen shortly, under open access conditions. The sectoral immobility of vessel owners and the characteristics of the crew in the fishing industry, will also add to the entry/exit gap in a fishery. In the Kedah/Perlis trawl fleet capital and labour have been cited as being rather immobile because of low opportunity costs in other fishing and non-fishing activities.

Under open access conditions, the existence of potential rent will lead to an increase in total effort via entry of new vessels ($pq_i X > s_i'$) and increase in rate of effort of existing vessels ($pqX \geq C_i'(E_i)$) The resultant increase in total effort will reduce the biomass X over time. Given the growth externalities inherent in the surplus production function which determines the level of biomass, the fishery supply function is clearly an increasing function of X. The fishery will therefore eventually converge to an equilibrium $\bar{X}$, where

$$(22) \quad B(\bar{X}) = q\bar{X}\sum_1^{\bar{N}} \bar{E}_i$$

where the right hand side is the fishing effort supply curve and the left hand side is the surplus production function (equation 2).

If labour and capital are perfectly malleable in open access zzshery, an equilibrium will be reached where each vessel will operate just at the minimum of its average cost curve ($pq\bar{X} = s_{\bar{N}}$, where $\bar{N}$ = number of vessels remaining in open access equilibrium). All the rent emanating from the resource will have been dissipated via the stock externality by an inflow of capital and labour.

The existence of a non-malleability gap creates a potentially unstable equilibrium [Clark, Clarke and Munro, 1979] and considerable ambiguity in predicting conditions under bionomic equilibrium. What can be said is that the inframarginal vessel will exit the fishery, the marginal units will operate just at the minimum average cost and the remainder vessels will earn positive rents [Clark, 1980, p.1114], that is where

$\max s_i \leqslant pq\bar{X} \leqslant \min s_i'$, $0 < i < \bar{N}$. The sum total of these returns, which constitute producers' surplus, could, relative to total cost be negative. The total producers' surplus relative to variable cost would, however, be positive.

Vessels of different efficiency levels can be expected to exist in a fishery. Vessel owners must make investment decisions on the basis of imperfect information on a risky and uncertain resource. Vessel designs and input combinations characteristically evolve through the trials and errors of more innovative vessel owners. The less adventurous vessel owners adapt the resultant innovation only if they are perceived to be profitable investments.

Price shifts and technological innovation can be expected to result in periodic changes in open access equilibrium. Real price shifts will lead to further increase in already excessive use of inputs [Copes, 1972]. If the level of demand rises high enough relative to costs, price rises could eventually result in the extinction of the resource [see Anderson, 1977, p.98 for a discussion].

Technological innovations are always a significant factor in fisheries even when under open access equilibrium conditions. New innovations adopted allow the vessel to earn rents through cost reductions. Rent so generated will eventually be dissipated as before resulting in a new equilibrium at a lower $\bar{X}_2$. The lower equilibrium $\bar{X}_2$ will force the non-adopting marginal vessels to exit the industry or to suffer losses.

The maximum static economic yield (MEY) is determined by the following classical constrained optimization problem:

$$(23)\quad \max \sum_i^N \pi_i(X,E_i) - \lambda(b(X) - qX\sum_i^N E_i)$$

where π_i is the maximum and the necessary conditions are:

$$(24)\quad (p-\lambda)qX = C_i'(E_i) \qquad i = 1,2\ldots N$$

$$(25)\quad = \frac{C_N(E_N)}{E_N}$$

From the necessary conditions we have:

$$(26)\quad C'(E_i) = s_N = \frac{C_N(E_N)}{E_N}$$

which states that a marginal vessel operates at its minimum average costs. Furthermore, the shadow price of the resource stock can be obtained from the necessary condition,

$$(27)\quad \lambda = p - \frac{s_N}{qX}$$

The minimum point of the average cost curve for marginal vessel can be obtained:

$$(28)\quad s_N = \frac{pqXb'(X)}{b'(X) - \bar{b}(X)}$$

where $\bar{b}(X) = b(X)/X$ is the average production of resource which in conjunction with the constraint function can solve the optimal values of X and N, the optimal solution is thus completely specified.

On the assumption of perfect malleability the equilibrium conditions of MEY are:

(29) $(p-\lambda)qX = s_N$ and $F(X) = qXE(N)$.

The dynamic optimization problem is arrived at in a similar manner. Again assuming perfectly malleable capital and labour, the economic optimization of fishing over time is the following:

$$(30)\quad \max \int_0^{\infty} e^{\delta t} \sum_1^N \pi_i \, (X_i E_i) dt$$

subject to

(31) $dx/dt = B(X) - qX \Sigma E_i$

and

(32) $X(t) \geq 0$, $E_i(t) \geq 0$, and $0 \leq N(t) \leq N_0$

where

δ = instantaneous social rate of discount

N_0 = maximum number of vessels able to operate on the fishery in a given period

$X(t)$= state variable

and $E_i(t)$ and $N(t)$ are control variables $i = 1,2,...N$

The necessary conditions for an interior solution are obtained following Pontryagin's generalised maximum principle [Clark, 1980, p.1116]:

(33) $C_i'(E_t) = (p-u)qX \qquad i = 1,2....N$

(34) $C_N(E_N)/E_N = s_N$

(35) $du/dt = (\delta - B'(X)u - (p-u)q\sum_1^N E_i)$

where u = costate variable or shadow price of resource.

These necessary conditions yield a unique solution for all variables similar to the static optimization problem,

$X(t) = X^*$, $u(t) = u^*$, $N(t) = N^*$ and $E_i(t) = E_i^*$

where

(36) $c_i'(E_i^*) = s_N^* = (p-u^*)qX^*$

(37) $u^* = p - s_N^*/qX^*$

and (38) $$\frac{pqX^*(B'(X^*) - \delta)}{B'(X^*) - \delta - \bar{B}(X^*)} = s_N^*$$

Equation 38 can be expressed as

(39) $$B'(X^*) + \frac{s_N^*\, B(X^*)}{qX^{*2}(p - s_N^*/qX^*)} = \delta$$

which is known as the modified golden run equation [Clark and Munro, 1975, pp.96-98]. The left hand side of equation 23 can be defined as the "own rate of interest" of the stock. Hence the golden rule states that at X^* the own rate of interest must just equal the social rate of discount.

The following ranking of open access (overbar) static optimum (unadorned) and dynamic optimum (asterik) equilibrium for each variable are easily obtained from the above equations

(40) $\bar{0} < u^* < \lambda$

(41) $\bar{N} > N^* > N$

(42) $\bar{E}_i > E_i^* > E_i$

(43) $\bar{X} < X^* < X$

The difference between the static and dynamic optimum conditions, as easily seen from equations 23 - 28, equations 31 - 39 is the discounting of time in the latter. Equations 40 - 43 show that an open access fishery, as a result of market failure (shadow price of resource = 0), involves too many vessels each using too much effort and resulting in over-exploitation of the resource. This set of equations also show that the specification of a time preference in the dynamic model results in higher optimal capitalization and lower biomass than in the static analysis.

The existence of a non-malleable gap in the optimization model leads to, as in the case of the open access fishery, an indeterminate solution. The optimal level of biomass (X^*) will lie within a range of $X_1^* < X^* < X_2^*$; the lower level determined by the exit and the upper level by the entry conditions.

Instead of the solution to the economic problem in equations 30 and 31, maximum sustainable yield (MSY) is often sighted as a suitable fisheries management goal. The argument is that harvesting a fish stock beyond MSY, defined as biological over-fishing, is inefficient because the marginal sustainable catch per unit of effort is negative. This argument originated with biologists using population dynamic models and is reinforced in the traditional models. However, the dynamic analysis shows that MSY is not a suitable management goal in that biological over-fishing can exist at optimal stock X^*. Equation 39 at MSY can be written as:

$$(44) \quad R = q \cdot X^2_{msy} \, (p - s_N / qX_{msy})$$

where $B'(X_{msy}) = 0$ and assuming $p > s_N$. The optimal stock size relative to the X_{msy} can be expressed as:

$$(45)\quad X^* \begin{cases} < X_{msy} & \text{if } \delta > R \\ = X_{msy} & \text{if } \delta = R \\ > X_{msy} & \text{if } \delta < R \end{cases}$$

In the static model where $\delta = 0$, and given that $R > 0$, $\overset{*}{X} > X_{msy}$, that is, biological over-fishing is always inefficient [1].

In cases where the modified golden rule (equation 39) fails to achieve a solution with $X^* > 0$, when $p > c(X)$, the optimum stock level is $X^* = 0$, that is, extinction is optimal. Clark and Munro [1979, p.200] have shown that the necessary conditions for extinction as the optimal result in the simple model argued above are:

$$(46)\quad p > c(0) \quad \text{and} \quad \delta > B'(0).$$

This states that in order for extinction to be optimal, price must exceed cost at $X^* = 0$ and the rate of discount must be greater than the own rate of interest (marginal stock effect is zero at $X^* = 0$). The sufficient conditions are:

$$(47)\quad p > c(0) \quad \text{and} \quad \delta > 2B'(0)\ .$$

When the assumptions of linearity and autonomy are relaxed, it becomes impossible to state the necessary or sufficient conditions for extinction.

The optimal approach path to the steady state solution, X^* in the dynamic analysis is the so-called bang-bang approach. The decision

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[1] There is a parallel discussion of the optimality of maximum physical yield in forestry, e.g. Samuelson, 1976.

criteria are:

(48) $N^*(t) = N_0^*$ whenever $X(t) > X^*$

(49) $N^*(t) = 0$ whenever $X(t) < X^*$

The bang-bang approach is optimal because vessels are assumed to be perfectly malleable and prices are assumed to be infinitely elastic. In reality the vessels are more often non-malleable and prices are affected by total supply. The optimal approach path in such cases would not be the most rapid possible but rather a more gradual approach sensitive to the market reactions to the harvest rate and vessel entry and exit conditions.

4.5 Regulation

A decentralised manager can, on the assumption of perfect malleability, achieve a socially optimal equilibrium via the imposition of a tax equal to the shadow price of the resource. In the static framework, the optimal tax rate per unit of catch would be λ = T where T is the rate of tax per unit of catch.

In a dynamic framework as discussed above, the socially optimal equilibrium can be achieved by means of a single tax rate, $u = T^*$. The imposition of a single tax rate (T^*) would achieve the optimal bang-bang adjustment by immediately driving out all those vessels for which $(p-T^*)qX < s_N$ $\quad 0 < N < N_0$.

In the more realistic contexts in which demand has a finite elasticity and entry and exit reactions are non-instantaneous, the adjustment path is more gradual. In such a case a single tax rate is not optimal. Under a more gradual optimal approach path, the shadow price of the stock is a function of time and subject to continuous charge as X^* is approached. The optimal tax rate would therefore also be a function of time.

An allocated transferable catch quota system can be shown to be equivalent, in terms of economic efficiency, to an optimal tax rate [Clark, 1980, p.1117; Maloney and Pearse, 1979]. The only necessary condition is that the sum total of all allocated quotas equal the optimal sustainable catch rate $B(X^*)$. Transferability of the quotas makes the initial distribution of the quotas irrelevant with respect to economic efficiency, since a quota market will lead to an efficient redistribution of quotas. The quotas would in the main come into the possession of the more efficient vessels. Auctioning the quotas would have the same effect in this regard but it would transfer all rent to the state.

A catch tax rate and an allocated transferable quota system, have seldom been imposed on a fishery for purposes of achieving optimal economic efficiency. The obvious reasons are, as in the case of the Malaysian trawl fishery, the dominance of political considerations as well as deficiencies in informational and institutional structures necessary for their implementation. A more commonly used tool for rationalisation of a fishery is a limited licensing scheme, such as the one instituted in the Malaysian trawl fishery. Although the economic efficiency is seldom the primary goal of a licensing scheme, such a scheme can be employed to determine an optimum fleet size albeit a second best one.

Under a limited licensing scheme with the aim of achieving an optimum economic allocation of resources, four questions, two technical and two distributional, arise. The technical questions are what is to be licensed and how many licences are to be issued. The equity problems concern who gets the licences and who gets the resource rent, if any.

It is assumed that (as in the Malaysian trawl fishery) N vessels are licensed, that these licences are non-transferable and that no charge beyond a small fee is levied on them. It is also assumed that each licensed vessel has a given production and cost function, modifications to which are effectively outlawed.

On the supposition that the optimum economic equilibrium has been established by equations 36 - 38, we know that the optimal catch rate $F(X^*)$ and the optimal use of effort E_i^* are determined by $c_i'(E_i) = (p-u^*)qX^*$.

The optimal number of licensed vessels, N, would be that for which the total effort level $\sum_i^N E$ just produces $F(X^*)$. Since under a limited licensing scheme in which no charge on catch rate equivalent to the shadow price of the resource (u) is levied, the licensed vessels operate under competitive conditions where $c_t'(E_i) = pqX$, $i = 1,2,..N$. The licensed vessels will thus employ an excessive level of effort(E_i) relative to the optimum (E_i^*). Nevertheless, the net economic return per vessel, which is

$$(50) \quad \Pi_i(X,N^*) = \int_1^y (pqXE_i - c_i(E_i))dt$$

where y is the time period for which the $F(X^*)$ is calculable, e.g. a year, will be positive and exceed capital cost, probably by a wide margin. The vessel would, through the possession of the quasi-property right, appropriate the resource rent. The extent of the suboptimality, $E_i > E_i^*$ is determined by the shape of the cost curve. If marginal costs rise sharply after an optimal level of E^* (after $E_i > E_i^*$), any distortion will be quite minimal.

An argument has been put forward by Crutchfield (1979) that restrictions on individual capital items e.g. tonnage and horsepower, can be used to force increasing marginal cost after E_i^*.

However, such restrictions would severely limit the flexibility of the vessels to adjust to changes in conditions. Flexibility is of primary importance in most fisheries given the high degree of uncertainty in the production process. Furthermore the cost functions and decision criteria of the vessels must be well researched in order to set these restrictions. Such a state of affairs does not exist in the Malaysian fisheries. The ingenuity with which the fishermen circumvent partial restrictions on capital is well documented. The efforts of the fishermen to render ineffective such regulations and the high informational costs will probably lead to spiralling administrative and implementation costs in such a program.

Where vessels exert effort in excess of the optimum E_i^*, a more realistic tactic would be to license fewer vessels than the optimum, $\sum_1^N E_i^* \rightarrow F(X^*)$. The second best optimum would be the minimum number of vessels (N_m) required to yield $F(X^*)$. The difference between this optimum and the optimum optimorum ($N_m - N^*$) would naturally depend on the cost functions.

The production and cost functions of vessels will undoubtedly change with the introduction of technological innovations. The incentive for adopting innovations is probably greater under limited entry than open access conditions. The adoption of innovations is also less risky under limited entry because profitability is more certain. Also, the only means by which a vessel owner can increase his profitability is by increasing the productivity of his licensed vessel, not as in open access conditions by increasing the number of vessels. However, the penalty for not adopting innovations is also less in the limited entry system. In general one would expect some increase in productivity of vessels under the limited entry arrangement unless the adoption of technological changes is prevented by political pressure.

Changes in the productive capacity of a fleet of licensed vessels will naturally necessitate the reduction in the fleet size if optimum equilibrium conditions are to be maintained. A mechanism must therefore exist through which the number of licences can be decreased. Increasing the number of licences of course poses little problem. Two such mechanisms are possible in the Malaysian industry. They are to simply retract some licences or to institute a buy-back scheme. The first option is politically difficult and economically suspect particularly with respect to the choice of vessels that are to exit. A buy-back scheme in which marginal or sub-marginal vessels are purchased by the management agency is not only more equitable but is also more economically efficient.

The distributional aspects of a limited licence scheme centers on who gets the resource rent. Excluding low rent fisheries and distorted distribution objectives, the fish stock is a natural resource the benefit of which should be shared by the population as a whole. The licensed vessel owner should be required to pay for the resource just like any other scarce resource. However, in the Malaysian case, licences have already been allocated so that the choice is between the licensed vessel-owner and crew or the management body (the nation). The crew should receive a portion of the resource rent appropriated by a fishery vessel because of the share system operating in most fisheries.

Resource rent accruing to vessels operating under a limited licence scheme, can be appropriated by the management body by selling licences at competitive auctions or by charging licence fees (beyond the small payment to cover costs of issue). In competitive auctions, the most efficient vessels should obtain the licences. The purchase price of the licence will equal the certainty equivalent of the rent from the fishery. The total resource rent will thus accrue to the management agency with minimal transaction costs. The licences are already distributed in the fishery under study so that the primary tool for redistributing any rent lie with a licence fee.

The value V_i of a licence, assuming the licence is transferable and if the bidders are risk-neutral [see Leland, 1978], will be equivalent to the net present value of expected future total resource rent:

$$(51) \quad V_i = V_i(X,N) = \pi_i(X,N)/\delta'$$

where δ' the time rate of preference is not necessarily equal to δ. The expectation of future rent will naturally be a function of the level of biomass and the number of licences. A managing agency could theoretically appropriate the total resource rent by taxing each licensed vessel a sum equivalent to the licences V_i.

A licence fee which is a lumpsum payment is primarily of distributional importance and is not itself a means of achieving economic efficiency. However, if the licences are transferable the more efficient vessel owners could be expected to buy out the less efficient. Furthermore, the funds provided by the licence fee could be used in the buy-back scheme. Of course some rent will accrue to the more efficient licence holders where there is a licence fee.

For a limited licence scheme to be effective, the licences issued must be differentiated by the productive capacity of the vessels. In order for the optimal effort E^* to be established, the issuing agency must know the range of production functions or vessel classes that exist. The task is to choose the number of vessels from each vessel class to be licensed such that $E_i^* \rightarrow F(X^*)$. If the licences are not issued relative to the productive capacity of the vessel, there is no means for choosing or regulating the total effort of the licensed fleet. The value of the licence must also be related to potential productive capacity for an efficient licence market to exist and for an accurate schedule of licence fees to be established.

4.6 Multi-Species Fisheries

A variety of biological models have been developed to describe multi-species fisheries. They can be divided into those that are general extensions of the single species surplus production or dynamic pool model and the more general models which consider the total ecological structure of the aquatic environment.

The surplus production model can easily be generalised to fit a fish stock, which is defined as the sum or pool of all species caught by a given fishing fleet. The pooled model has been used in the investigation of numerous fisheries such as the trawl fishery in the Gulf of Thailand [Marr et al, 1976], the eastern Pacific trawl fishery [Hongskul, 1975] and the west coast Malaysian trawl fishery [Pathansali, 1976]. In fact this has been the most commonly used technique for investigating multi-species fisheries. A result that seems to substantiate the validity of pooling the species, is that the surplus production model generally fits data on an aggregated fish stock better than its individual component species. The reason for this is the subject of a long standing debate [see FAO, 1978, p.17 and Pauly, 1979, pp.34-42]. An added advantage of the pooled model is that it can be incorporated into either a static or dynamic bionomic model.

The principal problem with an aggregative definition of a fish stock is that it does not explicitly consider the inter-relationships between the component species. Species which compete in any way for space, food etc. or have a predator-prey relationship are biologically inter-dependent. The harvesting process can affect these relationships leading to changes in the composition of catch through time. The alteration of the species-mix resulting from harvesting results in the ecological externalities identified above. The harvest of inter-dependent or multi-species fishery is examined in Anderson (1977) and Clark (1976). They show that the multi-species situation leads to an increase in the possibility of permanent instability and that optimal management necessitates explicit considerations of each component fish stock individually.

Alternatively, a multi-species fishery can be modelled by specifying a single species surplus production function for each of the component stocks. This method does allow the analysis of the differential effect of fish effort on the component species. Furthermore, the individual treatment of the stocks allows the examination of changes in allocation of effort amongst the species resulting from changing technology and prices. The major limitation of this procedure is that the stocks are assumed to be biologically independent. Clearly in a tropical demersal ecosystem the component species are not independent. The inter-dependence of the species will to a large extent invalidate results of the individual function through specification error.

The surplus production model can also be easily extended to take into account the effects of other species on the investigated species. The state equations for two single species fish stocks, X_1 and X_2 are simply:

(52a) $dX_1/dt = X_1r_1(K_1-X_1) - L_1X_1X_2 + V_2X_2 - F_1X_1$

(52b) $dX_2/dt = X_2r_2(K_2-X_2) - L_2X_2X_1 + V_2X_2 - F_2X_2$

(see FAO, 1978 pp.17-24 for a detailed discussion).

The only addition to the single species case is the simple interaction term L_i, which can take either sign, depending upon whether the species are complementary or competitors. Any number of species can be included in a similar manner, though it requires a considerable number of variables (equal to $(n+1)^2-1$, where n = number of species). The model has been estimated in a number of studies [e.g. Walter and Hogman, 1971, Pope, 1976, and Pope and Harris, 1975).

The difficulty with a multi-species surplus production model in the context of the Malaysian trawl fishery is the use of catch per unit effort (U) as an instrumental variable for population abundance. The estimation procedures outlined in the first few sections of this chapter can easily be extended to include additional species simply by incorporating the U of other species in the regression. However, the correlation between catch per unit effort of the component species will not necessarily show the biological inter-relationships amongst the species. Other factors such as changes in allocation of effort, commonality of life history, environmental fluctuations and sampling error will also affect the correlation of the species through time. The non-inter-dependent factors will not, particularly in the case of the Malaysian records collected, have just minor impact. Another problem with the multi-species production function in the same Malaysian context is the limited catch and effort records (10 years). The available records clearly do not allow the estimation of a fully specified multi-species model. In fact the small degree of freedom, even in the simplest two-species model, is extremely low.

The dynamic pool models cannot be employed on a pooled fish stock for they require specific information on recruitment, natural mortality and age composition of the species. But the dynamic pool models can be extended to consider species interactions in a manner similar to that described above for the surplus production model. (See Anderson and Ursin, 1977, for an analytical and empirical discussion.) Unfortunately, the practical problems of mathematical complexity and equation estimation, even in the simplest types of interaction and number of species, are prohibitive.

The whole system models are based on the premise that a fish stock cannot be studied in isolation. Rather a complete range of oceanographic or limnological factors must be explicitly considered. This is probably the best approach in terms of quality of biological estimates and as a basis for the bionomic analysis, but is far beyond the scope of this thesis.

4.7 Tropical Multi-Species Fisheries

Tropical ecosystems differ fundamentally from high latitude ecosystems with respect to the evolutionary characteristics of the component species. The divergence between tropical and temperate zone ecosystems is a result of dissimilarities in the availability of environmental resources such as food, space and energy. In temperate climates environmental resources are subject to significant and often unpredictable fluctuations. Mortality is therefore non-directed in terms of individuals, genotypes or phenotypes, and is relatively independent of population density.

Tropical ecosystems, however, have evolved under conditions of fairly constant and predictable climate and, consequently, a stable supply of environmental resources. Mortality in tropical ecosystems is therefore more directed, density dependent and generally favour those individuals with better competitive abilities. Ecological selection in temperate climate thus favours high fecundity and rapid development in contrast to tropical climates which favour lower fecundity and slower development (see Pauly, 1979 and Krebs, 1972).

The differences in ecological selectivity between tropical and temperate ecosystems are usually summarised in the ecology literature through the r-K continuum. r and K are the two parameters of the logistic curve (equation 4.2) where r represents the maximum intrinsic rate of growth and K represents the maximum population size determined by the carrying capacity of the environment. r selection in its extreme, e.g. in polar ecosystems, is where an organism is prevented from reaching its maximum density, K, because of the limited period for which environmental resources are available. r selection leads to an optimal strategy in which all energy and matter is put into reproduction with the smallest practical amounts put into each offspring. K selection is the other extreme in which organisms are able to survive long enough so that the population stabilizes near its maximum, K. Under K selection, replacement is the key and the optimal strategy is to place all energy and matter into maintenance and the production of a few extremely fit offsprings. Obviously, neither r nor K selectivity would prevail absolutely in any ecosystem; organisms have to adapt to a combination of the two forces.

Tropical fish stocks, like tropical ecosystems in general, would, in their virgin or unfished state, be expected to exhibit a high degree of K selectivity and thus a preponderance of K-strategists. In contrast, the temperate ecosystem would be expected to be largely composed of r-strategists.

Pauly (1979) found from studying the trawl fishery in the Gulf of Thailand that, as predicted by the above theory, the demersal marine communities in a virgin state were dominated by K-strategists. The species assemblage thus forms a stable, climax community with a classical food pyramid and very high species diversity. The bulk of the constituent species are small in size with few large predators.

Pauly (1979) also found that the rapid increase in trawl activity resulted in the disruption of the original ecosystem. Fishing effort effectively altered the competitive equilibrium of the ecosystem. The high rate of fishing mortality decreased the expected life of all species thus favouring r selective species. The dominant K selective small prey species were found to be replaced by generalist and/or r-strategist. The total biomass of the community was found to have declined, but the biomass of certain of the generalists or r-strategists had increased. Unselective fishing effort thus conceptually converted the tropical ecosystem into r selective temperate ecosystem.

Pelagic and semi-pelagic communities, in general, exhibit a high degree of r selectivity because of a less stable supply of environmental resources [Murphy, 1977]. The semi-pelagic community exploited by the Kedah/Perlis trawl fleet would then be expected, even in their virgin state, to contain a higher percentage of r-strategist Therefore trawling effort should not have as great a distortionary effect on the semi-pelagic community as it does on demersal communities. Furthermore, some of the semi-pelagic r-strategist may also be able to replace the demersal κ-strategist.

4.8 Differential Productivity

In the light of the above, it is instructive to explore the implications of jointly harvested species of differential productivity. Of particular relevance to the Kedah/Perlis trawl fleet is the question of whether the elimination of incidental κ selective species is likely and/or optimal. In the following we will (following Clark, 1976, pp.303-311) study the combined harvest of two biologically independent populations in the format of the basic fishery model.

Suppose that two biologically independent populations, X_1 and X_2, are harvested by a single fishery. Assuming that each population is adequately represented by a Schaeffer's surplus production model:

$$(53)\quad \begin{aligned} dX_1/dt &= r_1X_1(1-X_1/K_1) - q_1EX_1 \\ dX_1/dt &= r_2X_2(1-X_2/K_2) - q_2EX_2 \end{aligned}$$

where

$$E = \sum_1^N C(E_i) ,$$

total fishing effort and all other parameters are as described above. The total net revenue for the fishery, assuming perfect malleability of capital and labour, is then

$$(54)\quad \pi_i(X_1,X_2,E) = p_1q_1X_1E + p_2q_2E - C(E)$$

where

$$C(E) = \sum_1^N C(E_i)$$

Simultaneous equilibrium solutions for the logistic functions $\dot{x} = \dot{y} = 0$ can only occur where either x = 0 and/or y = 0 or on the line segment:

(55) $r_1/q_1(1-X_1/K_1) = r_2/q_2(1-X_2/K_2)$

$$0 \leq X_1 \leq K_1$$

$$0 \leq X_2 \leq K_2$$

Let us suppose that X_1 is a K selective species and X_2 is a r selective species with equal catchability coefficients $q_1 = q_2$. We thus have:

(56) $r_1/q_1 < r_2/q_2$

where r_i/q_i is defined as the biotechnical productivity (btp) of the ith population. Equation 55 will then intersect the X_2 axis, as illustrated in Figures 4.1a and 4.1b, at

(57) $X_2 = K_2(1-\frac{r_1q_1)}{r_2q_2}$

Bionomic equilibrium under open access conditions is characterised by the equilibrium line (Equation 55) in conjunction with the condition

(58) $(X_1,X_2,E) = 0$

There are two possible outcomes under open access equilibrium, assuming of course that the fishery is capable of yielding rent. One

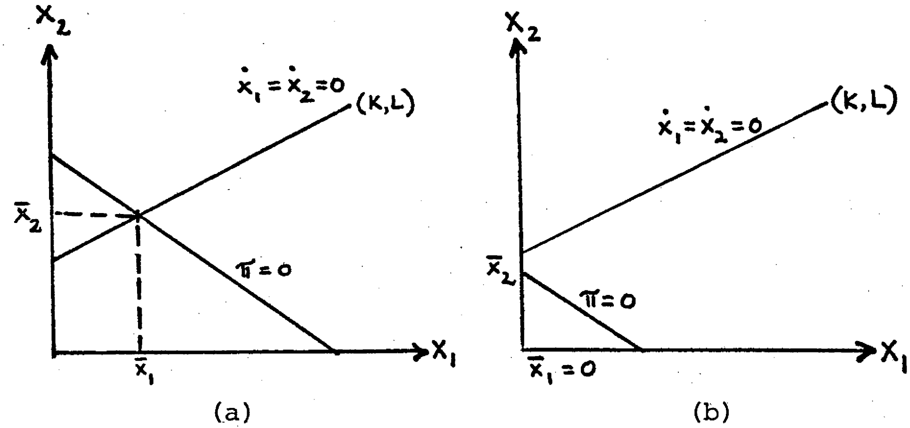

FIGURE 4.1: BIONOMIC EQUILIBRIUM FOR A TWO-SPECIES FISHERY: (a) NON-EXTINCTION; (b) EXTINCTION OF THE X_1 POPULATION

Source: Clark, 1976, p.304.

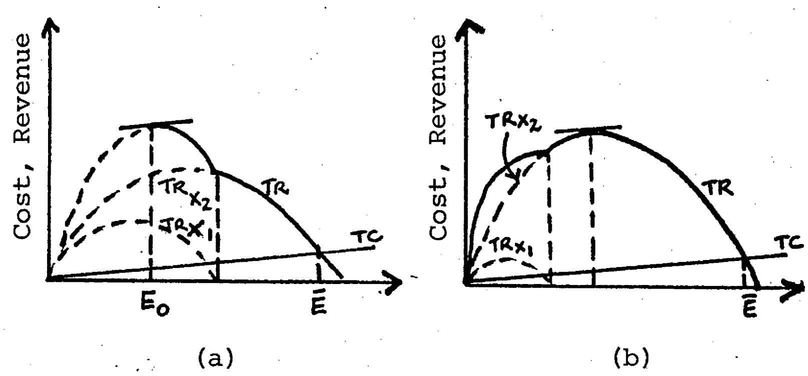

FIGURE 4.2: SUSTAINED REVENUE AND COST CURVES FOR THE TWO SPECIES FISHERY: (a) X_1 POPULATION OF GREATER VALUE, AND (b) X_2 POPULATION OF GREATER VALUE

Source: Clark, 1976, p.308.

potential eventuality shown in Figure 4.1a is that neither population is eliminated under open access $(\bar{X}_1,\bar{X}_2)$. The other alternative is that the zero profit line ¶= 0 does not intersect the the equilibrium line so that bionomic equilibrium occurs at point $(0,X_2)$, Figure 4.1b.

The necessary and sufficient conditions for X, not to be eliminated under open access equilibrium derived from equations 57 and 58 is

$$(59)\quad C/p_2q_2 > \bar{X}_2$$

The general rule is that populations with low btp, such as k strategists, are subject to elimination under joint harvesting provided that the cost price ratio of other species are sufficiently low.

Having solved equation 4.3, $\dot{x} = \dot{y} = 0$ for X_1 and X_2 in terms of E we have the total revenue (TR) for the industry

$$(60)\ TR = p_1q_1K_1E(1-q\ E)/r_1 + p_2q_2E(1-qE)/r_2$$

TR is thus the sum of the two yield-effort curves multiplied by their respective prices (p_1,p_2). In Figure 4.2a and Figure 4.2b, the situation where open access leads to extinction of X_1 is depicted. If the X_2 population is capable of generating greater resource rent than X_1, then, as shown in Figure 4.2b, the rent maximising level of effort E will lead to the extinction of X_1. If, however, the X_1 population is capable of generating the greater share of total economic benefit, then, as shown in Figure 4.2a, the maximisation of sustained economic rent leads to maintenance of the X_1 population. Open access exploitation, under conditions described in Figure 4.2b, is particularly disastrous for it leads to the destruction of valuable renewable resource and leaves behind only the less valuable stock, X_2 .

The implication of the above analysis is that open access conditions in tropical fisheries, especially those executed on demersal stocks, are likely not only to lead to over-fishing and over-capitalization, but also to extinction of valuable stocks. However, some of the more 'incidental' species in such fisheries will be eliminated under optimal conditions.

4.9 Analytical Models and Empirical Applications

Dynamic models of fisheries have been developed to consider a wide range of extentions to the simple dynamic model presented above. Plourde (1970) and Smith (1974) analysed the dynamic optimization process in a general equilibrium two goods and two sectors context. Munro and Clark (1979) examined the optimal taxation or subsidy rate under conditions of unemployment in the fishery and in the regional economy. Smith (1969), Quirk and Smith (1970), Clark (1976), Leung and Wang (1976) explicitly considered the investment-disinvestment process with a behavioural reaction function. Brown (1974) included the possibility of crowding externalities and Smith (1969) dealt with crowding and growth externalities. Clark (1976) and Hannesson (1975) developed dynamic models based upon dynamic pool and time- metered or discrete population dynamic models.

There have been a few empirical applications of dynamic models to practical fishery management questions. Strand (1975) applied a dynamic model based on Smith (1969), which used a series of dynamic pool models to assess the optimal economic fleet size of the trawl fishery in the east coast of the United States of America. Spence (1973) used an optimal control theoretical model to study the blue whale, as did Henderson and Tugwell (1978) in the study of the lobster industry on the east coast of Canada. Both of these studies estimated the population dynamic models and economic production functions separately in order to eliminate the necessity of specifying the production function as linear in effort. A number of studies have used dynamic models on renewable resources other than fish (see Peterson and Fisher, 1977, p.691 for bibliography).

There are, however, two major limitations of the received models that prevent them from being employed empirically in the investigation of most fisheries. First and foremost, the maximum number of variables or dimensions allowable, in order to achieve a computationally feasible solution is very small, not much beyond the simple dynamic model outlined above. The Malaysian trawl fishery, like most of the world's tropical fisheries, is a multi-species, multi-gear fishery. It thus has numerous state and control variables (at least 46). This effectively precludes the use of an optimal control theory framework. Aggregating, the dimensions of the fishery so as to fit the dynamic models would, because of the degree of aggregation required, preclude examining many of the more important biological and economic considerations. The other important limitation of the received dynamic model is that the optimization process is too simple. The optimal control theory, underlying the models, assumes that an objective and constraint function exists, through which various stationary time paths can be compared to produce an inter-temporal optimal equilibrium. In other words, it describes how a fishery would work if it worked optimally.

No matter how placid the economic environment and accurate the function set, firms or bureaucracies rarely act optimally. The existence of sub-optimality would be the expected norm in fisheries due to their inherent instability even under managed conditions and the high political input of most decisions. Sub-optimal behaviour should therefore be specifically considered when modelling a fishery.

4.10 Simulation Models

A number of biological simulators have been developed to examine and predict the effect upon a fish stock resulting at alternative levels of fishing effort. Deveny et.al. (1977) developed the MIT model which, with a choice of population dynamic models, simulates a single species of stock exploited by a multi-class fleet. NORSIM I [Hongskul, et. al.,1974] again allows for a range of population models in simulations of up to eight independent fish populations by up to six categories of fishing units. This program permits the separate examination of each vessel class's fishing effort upon each fish stock. Unfortunately, the stocks in Norsim I are assumed to be independent. Another simulation model, Fish 2 [Sarabun, 1979] is capable of studying both the biological and technical interactions of a two species fishery. This model allows the choice of either a deterministic or stocastic dynamic pool model.

Two simulation models have been developed to forecast the benefits accruing to public management of multi-species fisheries. They were motivated by the inadequate dimensionality of optimal control theoretic and dynamic programing models. The models are composed of two sections, i.e. biological and economic, interacting through time. In the older model NORFISH II [Huppert et. al., 1974], the NORFISH I biosimulator is employed as the biological sector. In the other model DYFISH [Curtis, 1979], the FISH 2 program is used. The economic sectors are simply a series of demand and cost equations, one for each species and fishing unit class.

Given, 1. the initial stock sizes,

2. the initial level and composition of total effort and the rate of adjustment

3. the number of years over which the adjustment is to take place, and

4. the number of years over which the fishery is to be evaluated (T),

the biological sector estimates the catch by species and vessel class for each year. The economic sector receives the catch information and estimates the net economic value (profit plus consumer's surplus). When time, T, the end of the evaluation period is reached, the economic sector estimates the present value, given a rate of social discount, of the stream of net economic values. The adjustment of effort and rate thereof that yields the highest NPV is interpreted as the optimal level of fishing effort.

Although these simulation models are able to explicitly consider a large number of variables, they are still very limited in their usefulness for management. Unlike the dynamic models which have a decision rule for selecting from amongst various adjustment paths, the simulation model depends upon assumptions regarding the period and rate of adjustment. Also, as in optimal control theory, the functional set is too simple for many management questions. The simulation models can consider autonomous shifts in the function sets, as well as sub-optimal decision making more easily than the optimal control model. However, the simulation programs are essentially partial equilibrium models and are thus incapable of modelling the economy-wide effects of a fishery rationalizaton program.

A modified version of the NORSIM II simulation program will be used in Chapter 8 to examine the potential rent available from alternative fleet sizes. The NORSIM II program was selected primarily because of its ability to more fully comprehend the dimension of the Kedah/Perlis trawl industry.

The NORSIM II program was modified in a number of ways to fit the particular features of the FT fleet. The biological and economic sector was expanded to include up to 32 fish stocks and 16 vessel types. Also a variable yield population model was added to examine alternative assumptions concerning the potential yield of some populations. The economic sector was altered to consider individually the harvesting and marketing operations of FT firms. The price and cost functions were altered to allow non-autonomous shifts (Appendix B gives a description of the simulation program).

CHAPTER 5

EMPIRICAL ANALYSIS OF PRODUCTION

5.1 Scheme of Chapter

The main concern here is to establish standardised fishing effort and catch per unit of standardised effort (CPUSE) for the purpose of determining the surplus production functions of the Kedah/Perlis trawl fleet in the next chapter. Consistent with the procedure already discussed in Chapter 4, this chapter sets out systematically the considerations necessary for their calculations. As trawl fishing in Kedah/Perlis is an industry with multiple-output, multiple-plant (i.e. vessel) firms, there are many of these rather involved considerations. It is therefore proposed to briefly outline here the main steps to obtain the standardised fishing effort and catch per unit of standardised effort.

First the Kedah/Perlis trawl fleet must be disaggregated into distinct trawler types or classes. Their fishing power and fishing effort are then individually estimated. This enables the identification of key vessel characteristics and groupings thereof which represent the primary decision variables of technological change and vessel productivity. Future fishing effort and fleet composition can then be predicted on the basis of changes in the composition of the classes.

Second, changes in the fishing area and nominal effort must be converted into standard units.

Third, the multiple outputs, that is, the 94 reported catch categories, are classified on biological and economic bases to reduce dimensionality.

Fourth, catch per unit of effort (CPUE) can then be estimated for the ultimate purpose of estimating the surplus production available from the populations at alternative levels of economic activity. CPUE, together with nominal effort and the number of operating vessels, can also be used to calculate the annual catch per taxon and the catch of the combined trawl fleet. These two calculations are in fact made and compared with corresponding published data. This additional exercise shows any divergence between the two sets of information. It is also used to show trends in total catch by community and trophic level of the total fleet as well as the FT fleet.

Fifth, to standardize fishing effort, it is necessary to adjust nominal effort of all vessel-gear types by their respective relative fishing powers. This part therefore estimates relative fishing power using the FPOW program and standardises fishing effort.

Catch per unit of standardised effort is finally estimated.

5.2 Classification of Trawl Fleets

The methods of classifying individual vessels, although little discussed, are often a significant source of imprecision in the estimation and control of fishing effort. The customary practice is to choose a physical characteristic of the vessels known to be significantly correlated with vessel productivity, for example tonnage, and subdivide the fleet, on the basis of technical knowledge and/or, where expedient, into classes representing fixed ranges of the chosen characteristic, for example 30 - 40 tonnage class. The assumption underlying this is that each vessel class represents a unique and homogeneous vector of inputs so that any significant change in an individual vessel's fishing power will cause a change in classification. The validity of such an assumption ultimately depends on the choice of the grouping characteristic, its technical relationship to other inputs and the range of each group.

Here, a satisfactory classification characteristic for appropriate groupings will be selected from the determinants of vessel productivity and the degree of inter-dependence among the vessels. As a prelude, the technological changes undergone by the fleets over the last 15 years must be discussed for the determinants of vessel productivity are identified therein.

5.2.1 Technological Changes in the Trawl Fleet

Progressive technological change experienced by the FT fleet since 1969 centred around the expansion of the propulsion unit. Between 1965 and 1969, there was little variation in the tonnage or engine size of the FT fleet: all its trawlers were between 25 - 35 [1] tonnes with engines of 100 - 159 horsepower and gear boxes of 2:1 ratio and used nets of identical size. The industry expanded in the first five years. The Thai and prawn trawl nets and standard propulsion unit produced satisfactory profits which could be enhanced by enlarging the total fishing area. In 1971, the Fisheries Division's research centre at Glugor in Penang introduced a high opening fish trawl net, probably in response to the concern over the relative decline in demersal stocks. The high opening net has longer head and foot ropes producing a larger mouth area which together with increased floatation and weights increased access to semi-pelagic

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[1] Trawl owners had built up the sides of their 25-30 tonne vessels thereby creating unstable vessels, to meet an early requirement that all trawlers must be over 50 tonnes.

populations. Its 9-inch wing mesh (as compared to the 3.5-inch mesh of the Thai trawl) enabled existing trawlers to pull the larger net through the water after the swifter semi-pelagic species. Its performance was enhanced beyond that of the Thai trawl by increased trawler power and speed through improvement of the propulsion unit.

By 1974, the high opening trawl had completely replaced the Thai trawl presumably because it was profitable. Adaptation of the high opening net led to the continuous introduction and assimilation of new technology designed to augment and increase engine power. The 175 h.p. Mercedes engine and 3.1 reduction engine gear box had been introduced simultaneously with the high opening net in 1971. The equally powerful and more efficient IZUZU 165 horsepower engine appeared in 1973 and the 190 horsepower Cummins engine swiftly replaced the smaller engines. The manual 4:1 ratio gear box grew in tandem with the Cummins engine but has in recent years been replaced by the hydraulic 4:1 and 5:1 ratio gear boxes. As the size of the high opening net is built according to the size of the engine and gear box, the average size of the fishing net has increased steadily from 1971.

The prawn trawl fleet has not experienced any dramatic technological change since the late 1960s although a number of engine makes and sizes have been replaced by the more efficient and powerful ones. For example, a large number of PKT vessels switched from 60 - 100 h.p. engines to 140 h.p. Leyland and 175 h.p. Mercedes engines and in more recent years to 190 h.p. Cummins engines. The prawn trawl used by the FT fleet too has undergone little change. Its size, as in the case of the high opening net, is a function of engine size but its increase relative to engine size is at a slower rate than the fish trawl. Since the prawn trawl concentrated on the bottom dwelling species, it was unimportant to obtain faster vessels.

5.2.2 The Primary Determinant of Trawler Productivity: Horsepower

In the light of the foregoing discussion, the primary determinant of trawler productivity seems to be, a priori, the horsepower of the engine especially in the case of fish trawlers. This a priori determinant coincides with the results of simple correlations amongst specified inputs.

The fish trawlers, in accordance with the fleet's pattern of technological changes since 1969, exhibit a high positive correlation between engine horsepower and gear box size and daily and annual diesel consumption (see Table 5.1). The simple correlation of every specified variable, except crew size and tonnage, with horsepower is larger than their correlation with any other specified input. Tonnage is correlated but only marginally with gear box size. Table 5.1 also shows a negative correlation between crew size and year and the absence of significant correlation between days fished and any other specified input.

A similar relationship between engine horsepower and other inputs is evident in the case of the prawn trawl fleets (see Table 5.2). In the SPT fleet, engine horsepower has a higher positive correlation with tonnage, crew size and gear box size than any of the other inputs. The same pattern exists in the PKT fleet. The major difference in the pattern of correlation coefficients between the prawn trawl and the FT fleets is the general absence of any correlation in the former between year and daily diesel consumption and any other specified input which seems to substantiate the

TABLE 5.1 : CORRELATION MATRIX OF SPECIFIED PHYSICAL AND OPERATING CHARACTERISTICS OF FT VESSELS FOR WHICH PANGGU RECORDS [1] WERE OBTAINED

	Days Fishing	H.P.	Ton.	Gear Box Size	Year	Diesel Consump.
Days Fishing	1.0					
H.P.	0.163*	1.0				
Tonnage	0.072*	0.154	1.0			
Gear Box Size	0.163*	0.641	0.260	1.0		
Year	0.054*	0.686	0.022*	0.573	1.0	
Diesel Consump.	0.046*	0.486	0.112	0.279	0.448	1.0
Crew Size	0.061*	-0.282	0.176	-0.326	-0.523	-0.360

[1] Annual Data from Annual Boatlists and panggu records

* Insignificant at a 5% level.

TABLE 5.2 : CORRELATION MATRIX OF SPECIFIED PHYSICAL AND OPERATING CHARACTERISTICS OF SPT AND PKT VESSELS FOR WHICH PANGGU [1] RECORDS WERE OBTAINED

	Days Fishing	H.P.	Ton.	Gear Box Size	Year	Diesel Consump.	Crew Size
Days Fishing	1.0	0.085*	0.091*	0.067*	-0.046	-0.535	0.132*
H.P.	0.09*	1.0	0.569	0.572	0.170	-0.035*	0.463
Tonnage	0.121	0.822	1.0	0.599	0.073*	-0.012*	0.293
Gear Box Size	0.016*	0.595	0.452	1.0	0.192	0.010*	0.042*
Year	0.213	0.096	0.201	-0.066*	1.0	0.046*	0.107*
Diesel Consump.	0.048*	0.241	0.278	0.219	-0.146	1.0	-0.108*
Crew Size	0.102*	0.694	0.64	0.478	0.027*	0.176	1.0

SPT Fleet

<------PKT Fleet------>

[1] Annual Data from Annual Boatlists and panggu records

* Insignificant at a 5% level.

earlier statement that the basic prawn trawler in both the SPT and the PKT fleets has not changed significantly over the years. Further, days fished does not appear to be correlated with any other specified input in either prawn trawl fleets.

5.2.3 The Primary Determinant - According to the Production Function

By estimating a number of alternative specifications of the production functions by ordinary least square regressions, it is possible to statistically test the validity of horsepower as the primary determinant of vessel productivity.

Although the exponential production function has several properties which make it inappropriate for much applied research (e.g. essentiality of outputs, homotheticity and unboundedness), its manipulative capabilities and simplicity of estimation enable it to provide satisfactory explanations. Furthermore, it can provide local approximation since essentiality and unboundedness are boundary properties. It is consequently the only function used since it is not the intention here to measure the technical relationships between inputs.

a) Production function specified

The neoclassical production function for an individual plant (i.e. vessel) specifies output as a function of labour, capital and natural resources and measures it as a flow of goods per unit of time. The input variables represent different kinds and qualities of labour, capital and natural resources used to produce the output. It also assumes that the specified input set produces the output as efficiently as possible.

The production function is used here to estimate the marginal contribution of each specified input and the total contribution of all specified inputs to variation of output. Output will be defined in terms of total weight of fish landed, total revenue, total weight landed per day and revenue per day. Total weight and revenue are used to identify the variability in output proportions. Total weight per day and revenue per day are specified for the purpose of testing the importance of days fishing, that is nominal fishing effort. Labour is measured by size of crew and capital by the physical qualities of equipment used. Data are available on engine horsepower, vessel tonnage, and gear box reduction ratio. Diesel consumption per day is included in the total revenue and revenue per day functions as an additional measure of capital quality. Here the underlying idea is that the speed and power of a given propulsion unit is proportional to diesel consumption per day and hence proportional to fishing power.

The year of the data set helps to remove the effects of inter-year changes in stock availability and abundance. The equation with total weight landed as a measure of output, is estimated using monthly rather than yearly data because trip receipt records for a given vessel were often unavailable for a complete year. Besides, monthly data enable us to test the significance of seasonality in determining total catch. A dummy variable is included in the equations estimated from trip receipt data and set equal to 0 for season 1 (December through February), 1 for season 2 (March through May), 2 for season 3 (June through August), and 3 for season 4 (September through November). The equations specifying total revenue and revenue per day are estimated with annual data from panggu records.

b) Output defined

Output may be defined as the weight of total landings or the realized revenue. The operational objective of a profit maximising captain exploiting a multi-species resource is not likely to be the weight of total landings. The theoretically more plausible objective, given that fishing vessels are primary producers and hence all sales revenue is value added, is to maximise total revenue. The degree to which these two measurements diverge is determined by the ability and motivation of the captain to alter the species composition of the catch. The ability to adjust the proportions of the various species harvested is determined by the extent to which the exploited populations are spatially and temporally segregated and the extent to which the trawler and the crew can technically exploit any distributional difference.

The desire to adjust the catch composition inorder to increase expected profits is naturally governed by the expected relative prices and catch rates of the potentially harvestable species. In a biologically complex fishery, total weight and total revenue would be equivalent measures of output if the harvested populations were thoroughly mixed in point of time and area such that the probability of locating one population or school is low per unit time. In this case the fishermen will attempt to catch all they can of the populations they do locate. If the fish populations are equally catchable and their prices not too different, revenue will be a linear transformation of weight and the two measurements can be used interchangeably.

However, marked dissimilarities are present in prices and catch rates of the exploited populations which provide the impetus to adjust the composition of output. It is known that the species mix can be affected by the appropriate choice of technology and the captain's skill. For example, the fish trawlers can enhance the catchability of semi-pelagic species if their propulsion is increased. By using a fish net in the day and a prawn net or purse seine at night, they can also 'target' for certain species. Although prawn trawlers do not seem to use an alternative net, they can likewise enhance the catchability of target species of prawns by increasing their vessel power. These technologically and skillfully induced changes in catch will not necessarily lead to changes in revenue and weight in corresponding proportions.

It is not known to what extent variation in catch composition is affected by the captain's skill in concentrating fishing effort on certain populations. Neither information on the location of each haul nor a measurement of the captain's skill can be obtained. According to the captains interviewed, the semi-pelagic species, when in season, are concentrated in depths of between 30 and 40 meters and in the area just east of Langkawi Island. Prawns are often found concentrated in the lee of the inshore islands like Pulau Sanglang and Pulau Bidong. Concentrations of Pomfret, Cuttlefish, Squid and other valuable species in areas and at times known to knowledgeable captains are accordingly exploited by them.

In Kedah/Perlis, the trawl and purse seine firms are commercial entreprises whose utility maximising behaviour is mainly pursued through the maximisation of profits. The historical development of the large scale fishing sector in Malaysia was outlined in Chapter 2, and the economic structure and organisation of the Kedah/Perlis trawl and purse seine fisheries delineated in Chapter 3. These show clearly the commercial and capitalistic character of the fishermen under study. In our discussions with market agents and trawl owners, we attempted to identify and rank their firms' operation objectives. Invariably the primary goal was to maximise the profitability of every trawler and in so doing that of the firm. All vessels of a multi-vessel firm, including a market agent's fully tied vessels, are operated as separate units and no firm dominates. Otherwise, it could internalise the stock externality. The benefits to the owner (or the market agent) of owning (or controlling) a number of vessels include the economies of scale in the product and factor markets, the provision of a steady cash flow, the reduction of risk and uncertainty, and additional marketing income. The profit maximising paradigm regarding decisions of resource allocation of individual firms used in the bionomic models, presented in Chapter 4, is a close approximation to reality.

c) Estimation of production functions

The regression estimates of the F.T. fleets' production function are reported in Table 5.3. Revenue yields a good and far superior fit to the specified relationship, than does weight. The difference in fit between the two measurements of output and the specified input set must to a significant extent be due to the ability, either through choice of technology or the captain's skill, to harvest selectively according to the expected value of their yield. Notwithstanding this, several features of the revenue data may, through attenuation of variation, explain its superior fit to the specified relationship. The revenue data are in yearly aggregates or averages which would diminish variations in revenue caused by

TABLE 5.3 : ALTERNATIVE SPECIFICATIONS OF THE EXPONENTIAL PRODUCTION FUNCTIONS FOR THE FT, PKT, AND SPT FLEETS

Explanatory Variables [1]	Acc. Period	Days Fished	H.P.	Ton.	Gear Box Size	Year	Diesel Consump.	Crew Size	Season. Dummy Varia.[2] 1	2	4	Constant	R^2	F	D.W.
Dependent Variable					Fish Trawlers										
1. Total Katis	mthly.[3]	0.453	0.183	0.006	-	0.041	-	-0.033	0.276	0.047	-0.024	-4.117	0.38	68.53*	1.04
(t-ratio)		(16.79)*	(6.03)*	(0.23)	-	(1.34)	-	(1.18)	(8.52)*	(1.48)	(1.77)**				
2. Total Katis per day	mthly.	0.02	0.124	0.029	-	0.01	-	-0.033	0.262	-0.037	-0.037	-2.144	0.13	16.446*	1.01
(t-ratio)		(0.61)	(3.43)*	(0.90)	-	(2.78)*	-	(1.00)	(6.82)*	(0.99)	(0.97)				
3. Total Revenue	yrly. [4]	0.765	0.240	0.153	0.126	-0.029	0.078	-0.087	-			1.157	0.845	192.31*	1.51*
(t-ratio)		(30.13)*	(6.06)*	(5.41)*	(3.51)*	(0.73)	(2.55)*	(2.75)*	-						
4. Total Revenue per day	yrly.	-0.055	0.422	0.269	0.221	-0.051	0.029	-0.153	-			1.157	0.52	38.69*	1.51*
(t-ratio)		(1.24)	(6.06)*	(5.41)*	(3.51)*	(0.73)	(2.55)*	(2.75)*	-						
5. Total Revenue per day	yrly.	-0.055	0.405		-0.336	-0.068	0.199	-0.242	-			2.33	0.47	36.13*	1.12*
(t-ratio)		(1.18)	(5.52)*		(5.38)*	(0.93)	(3.59)*	(4.33)*	-						
					Pulau Ketam Trawlers										
6. Total Revenue	yrly.	0.923	0.175	0.069	-0.099	-0.06	0.008	0.051	-			1.455	0.93	452.29*	1.61*
(t-ratio)		(52.28)*	(4.54)*	(2.00)**	(4.18)*	(3.34)*	(0.46)	(2.07)**	-						
7. Total Revenue per day	yrly.	0.001	0.500	0.196	-0.283	-0.176	0.024	0.146	-			14.552	0.41	24.25*	1.61*
(t-ratio)		(0)	(4.54)*	(2.00)**	(4.18)*	(3.34)*	(46)	(2.07)**	-						
8. Total revenue per day	yrly.	0.006	0.646		-0.291	-0.154	0.041	0.173				13.213	0.40	27.29*	1.60*
(t-ratio)		(0.11)	(7.78)*		(4.28)*	(2.97)*	(0.78)	(2.49)*	-						
					Small Prawn Trawlers										
9. Total Revenue	yrly.	0.886	0.149	0.147	0.052	0.038	0.103	0.04	-			-1.784	0.91	72.92	1.34*
(t-ratio)		(17.81)*	(2.37)*	(2.79)*	(0.84)	(0.90)	(2.08)**	(0.83)	-						
10. Total Revenue per day	yrly.	0.058	0.283	0.279	0.098	0.071	0.195	0.075	-			-1.78	0.39	9.58*	1.34*
(t-ratio)		(0.62)	(2.37)*	(2.79)*	(0.84)	(0.90)	(2.08)**	(0.83)	-						
11. Total Revenue per day	yrly.	0.063	0.358		0.217	0.039	0.196	0.105	-			0.231	0.34	9.29*	1.30*
(t-ratio)		(0.64)	(2.99)*		(1.93)**	(0.48)	(2.03)**	(1.06)	-						

[1] Explanatory and dependent variables are in logrithmic form.
[2] The coefficient of the seasonal dummy variable 3 is zero and is not presented.
[3] The monthly catch data is from trip receipt records obtained in the course of this study.
[4] The yearly revenue data is from Panggu records obtained in the course of this study which are deflated by the consumer price index.

* - significant at 1% level.
** - significant at 5% level.

seasonal and other fluctuations in catch rates and prices. The high degree of seasonality in the catch rate is illustrated in equations 1 and 2 in Table 5.3. In both the catch and catch per day equations only the first season is a significant determinant of output. This implies that total catch, in terms of weight, is, ceterus paribus, determined by the success of the fishing activities from December to February. Variation in revenue is also likely to be reduced, relative to weight, by the tendency of the price to vary inversely with total catch. Prices at market and boat levels can be expected to be a function of the total supply at the port of landing. During days or seasons of high average fleet catch rates, prices at both levels would be expected to be low, off-setting high catch rates and thereby limiting the increase in revenue. The practice of market agents and fish trawl owners of varying indirectly the ratio of the boat-level price to market-level price with the size of the catch will also reduce the relative variance of revenue. This practice is related to another practice whereby market agents and trawl owners vary the share of marketing revenue inversely with total revenue. The catch data only cover the years 1973 to 1979 whereas the revenue data cover the entire 1969 to 1979 period and have more observations per year. Consequently a higher degree of sampling error and greater variation in the catch data are probable during the period sampled. In Chapter 7, the smoothing of revenue data will be pursued further.

Regressions for the three trawl fleets reported in Table 5.3, in general, substantiate the hypothesis that engine horsepower is the primary determinant of vessel productivity and the chief technological decision variable. Engine horsepower is the only specified input which is significant in all equations. Moreover vessel horsepower in all equations, except 9 and 10, has a larger t-ratio and standardised regression coefficient than any of the other inputs apart from days fishing. Vessel tonnage is an important explanatory variable of total revenue and revenue per day in all fleets. But when it is excluded from the regression as was done in equations 5, 8 and 11, horsepower and/or gear box size seem to pick up most of the variation attributed to tonnage leaving the equation unchanged. Gear box size is significant for the FT and PKT fleets but not the SPT fleet. However, the regression coefficient of gear box size is negative for all PKT fleets. The negative or negligible contribution of gear box size to the explanation of variation in the output of prawn trawlers strengthens the previous assessment that propulsion power is less important in prawn trawlers than in fish trawlers. The regression coefficient of diesel consumption further substantiates this.

The coefficient of days fishing in equations 1, 3, 6 and 9 is positive, significant and larger than any other specified explanatory variable. This together with the absence of correlation between days fishing and the other variables, seems to indicate that output measured either as weight or revenue, is proportional to the number of days at sea irrespective of the tonnage, engine size, gear box size and year. Thus far the foregoing supports the stratification of the fleets into classes representing a characteristic set of inputs and the expression of the rate of output for each class as quantity per day at sea. The equations specifying output per day, that is equations 4, 7 and 10, are the production functions of the fleets. All the production functions are significant although the fit, that is R^2, is not great especially in the case of prawn trawlers. A major reason for this, as will be shown in the next section, is that the important explanatory variable of management has been left out.

d) Management

Most research concerned with determining fishing vessel productivity and/or profitability have found the managerial ability of the decision makers, especially the captain's, to be a principal determinant variable [Heong,1951; Peace Corps, 1970; Comitini and Huang, 1967]. The Kedah/Perlis trawl and purse seine fisheries are undoubtedly no exception to this finding. However, we were unable to obtain sufficient information on the crews to construct even a crude index of managerial input. An observation we made was that the crews and, to a lesser extent, the skilled decision makers (that is the captain and netman) moved frequently amongst the vessels of a given fleet. The transient nature of the crews prevented records on them from being maintained and certainly made procurement of information on them by means of a survey financially prohibitive.

The ownership-control structure of the trawl and purse seine fisheries allocates the managerial decision primarily between the owner and/or market agent and the captain. The owners' primary function is entrepreneurial. He is responsible for long term decisions regarding such variables as choice of enterprise, technology to be employed, disposition of products, and the delineation of objectives. They also characteristically undertake the co-ordinating component of management, which involves determining the kinds of contracts to be entered into, ensuring that necessary inputs are available for the timely completion of tasks, and choosing the captain and engine man. Where the owner is an owner-operator, as are most prawn trawler owners, a market agent is usually hired to supply the co-ordinating functions except the hiring of the captain. The captain, whether as employee or owner, supervises the crew and equipment and provides the skill and knowledge to maximise boat level profit.

There are weighty indications that the three components of management, (i.e. coordination, supervision, and skill) account in no small way for variations in the species composition of the catch and number of days fishing. They include the following. First, significant variations in revenue per day remain unexplained by the physical and operational characteristics specified (see equations 4, 7 and 10 in Table 5.3). Second, since fishing area, time and gear (in equations 2 and 4 in the same table) were not random preferences but were chosen according to the type of fish population a vessel had for a target, the captain's skill in making the choices must affect the relative value of the catch. Third, although the number of days at sea is largely determined by factors often not within the control of management, (for instance breakdown of equipment, their overhaul and absenteeism of crew) able supervision and coordination can undoubtedly mitigate time lost thereby [see Peace Corps, 1970; Elliston, 1976; Heong, 1951].

Movement of trawl and purse seine crews among vessels, primarily in pursuit of larger incomes, results in the better skilled and more diligent crews serving on the more profitable vessels. In the FT fleet at least, over time the more successful captains acquire more capital and, apparently, in the form of vessels of heavier tonnage and larger engine size. This hypothesis predicts that bigger vessels are better managed. However, the absence of significant correlation between days fishing and the several characteristics in Tables 5.1 and 5.2 would seem to refute the contention that better crew is correlated with larger vessels which in turn is correlated with greater days fishing. Nonetheless it will be seen in section 5.4.4 that further scrutiny of days fishing per vessel class lends credibility to the relationships suggested.

An important management role in the determination of diesel consumption is discernible in the relationship between diesel consumption and the several physical and operational characteristics. Table 5.4 reports the regressions for each fleet wherein diesel consumption per day is specified as the dependent variable and days fishing, horsepower, vessel tonnage, gear box size and year as explanatory variables. The rather low R^2 values of 0.331, 0.131 and 0.338 for the FT, PKT and SPT fleets respectively is the salient point of the equation. Engine horsepower and gear box size, which one would on an a priori basis believe to be major determinants of diesel consumption, are only significant in the FT fleet. The gear box size regression coefficient in equation 3, however, is negative. In the absence of any bias due to specification error, this means that increased gear box size improves fuel efficiency unless there is simply a trend towards larger reduction ratio gear boxes.

The poor over-all fit of the regression in Table 5.4 also suggests the importance of management in the determination of diesel consumption as does an anomaly in the results for the SPT fleet equation. In the latter, the regression coefficient for days fishing per year is significant but negative. This implies that the more successful a SPT vessel was in increasing the rate of effort per year, the less efficient it was per unit of effort. A probable

TABLE 5.4 : EXPONENTIAL FUNCTIONS OF DIESEL CONSUMPTION PER DAY FOR THE SPT, PKT AND FT FLEETS

	Days [1] Fishing	H.P.	Ton.	Gear Box Size	Crew Size	Year	Constant	R^2	F
1. Small Prawn Trawlers									
Diesel consump. per day [2]	-0.574	-0.14	0.006	0.128	0.008	0.035	5.552	0.338	9.01*
(t-ratio)	(7.17)*	(1.14)	(0.05)	(1.06)	(0.09)	(0.42)			
2. Pulau Ketam Trawlers									
Diesel consump. per day	0.105	0.007	0.292	0.103	0.089	-0.211	5.064	0.131	6.303*
(t-ratio)	(1.74)**	(0.05)	(2.51)*	(1.26)	(1.05)	(3.40)*			
3. Fish Trawlers									
Diesel consump. per day	0.007	0.404	0.197	-0.173	-0.262	0.13	7.001	0.331	20.396*
(t-ratio)	(0.13)	(5.17)*	(3.43)*	(2.36)**	(4.13)*	(1.59)			

[1] All explanatory and dependent variables are in logrithmic form.
[2] Annual data.
* - significant at a 1% confidence level
** - significant at a 5% confidence level

explanation of this is that the more reliable engine types are also the least fuel efficient. If this is the case, management, in its choice of the engine type, unquestionably determines the diesel consumption.

5.3 Trawl Fleets Classed by Horsepower

A total of 24 engine types ranging from 4 to 195 horsepower have been used in the Kedah/Perlis trawl and purse seine fleets since 1969 but this diversity has through the years been greatly reduced. Each of the ten groups of horsepower in Tables 3.2 to 3.4 therefore represents at most a few engine types with a dominantly popular one. The two largest horsepower groups, 9 and 10, which include 2 and 1 engine types respectively, are major innovations adopted by the FT fleet after the introduction of the high opening trawl. These two groups are retained and referred to as Class D (160 - 179 h.p.) and Class E (180 - 199 h.p.) while the other eight groups are aggregated into three statistically homogeneous classes. The means of annual revenue, variable costs and net revenue per day fishing for each group, deflated by the consumer price index, were compared by the use of the student t-test. The group pairings where the means of each variable were statistically significant to a 10% level of confidence are presented in Table 5.5. On the basis of these results, groups 1, 2 and 3 were for the prawn trawl fleets aggregated into a single class, that is Class A. Likewise groups 4, 5 and 6, and groups 7 and 8 were lumped together to form Classes B and C respectively. The only exception to this classification scheme is the Class C fish trawlers. The variables of group 6 fish trawlers were found to be statistically equivalent to groups 7 and 8 fish trawlers. Moreover the mean

TABLE 5.5 : MEAN TOTAL REVENUE, TOTAL COST AND NET REVENUE BY INITIAL HORSEPOWER CLASS FOR FT, SPT AND PKT FLEETS AND GROUPINGS OF THE HORSEPOWER CLASS BY THE STATISTICAL EQUIVALENCE OF THEIR MEANS

	Total[1] Revenue	2-Tail Prob.[2]	Total Cost	2-Tail Prob.	Total Revenue	2-Tail Prob.	Obs.
Small Prawn Trawlers							
Class A							
Grp. 1 (0-19 h.p.)	72.68		29.47		43.22		10
		0.493*		0.518*		0.284*	
Grp. 2 (20-39 h.p.)	76.29		28.16		48.13		52
		0.450*		0.215*		0.173*	
Grp. 3 (40-59 h.p.)	72.86		30.03		42.83		17
Class C [3]							
Grp. 7 (120-139 h.p.)	106.50		39.31		67.19		6
		0.933*		0.293*		0.658*	
Grp. 8 (140-159 h.p.)	107.44		43.86		63.58		16
Pulau Ketam Trawlers							
Class A							
Grp. 2 (20-39 h.p.)	99.00		39.63		59.37		39
		0.455*		0.921*		0.678*	
Grp. 3 (40-59 h.p.)	89.19		40.26		48.93		2
Class B							
Grps. 4 & 5 [4] (60-99 h.p.)	113.09		48.51		65.57		21
		0.983*		0.616*		0.737*	
Grp. 6 (100-119 h.p.)	112.96		50.10		62.86		24
Class C							
Grp. 7 (120-139 h.p.)	125.59		51.78		73.80		24
		0.257*		0.205*		0.791*	
Grp. 8 (140-159 h.p.)	133.15		57.97		75.19		61
Fish Trawlers							
Class C							
Grp. 6 (100-119 h.p.)	168.99		71.47		97.53		6
		0.429*		0.686*		0.315*	
Grp. 7 (120-139 h.p.)	147.23		66.94		80.30		8
		0.67*		0.039		0.468*	
Grp. 8 (140-159 h.p.)	153.37		82.22		71.16		64

[1] The revenue and cost data are deflated by consumer price index, and include all boat-years of available Panggu records.

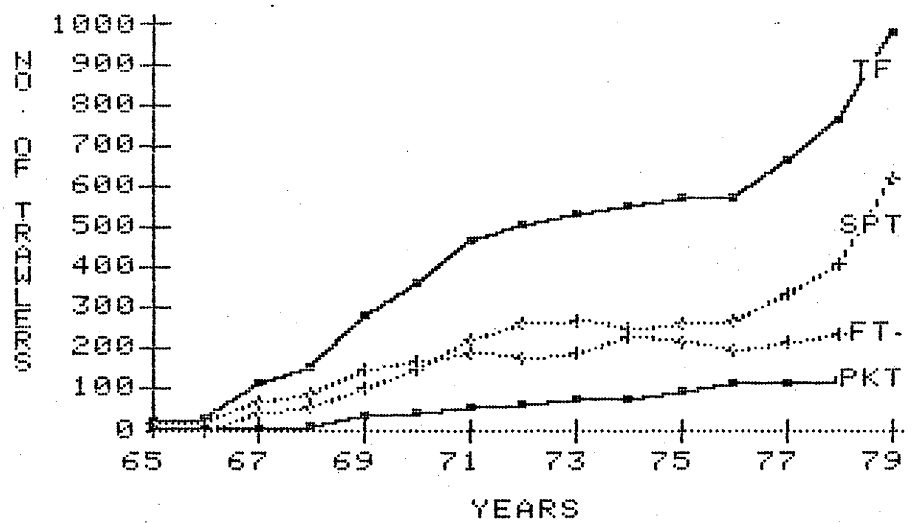
[2] 2-tail probability is derived from a t- test on the equality of means.
[3] Insufficient data is available for small prawn trawlers with 60-119 h.p. engines to adequately test the means.
[4] Horsepower classes 4 and 5 were aggregated because of the small sample size in class 5.
* significant at a 10% confidence level

variable cost per day of group 7 fish trawlers was not statistically equivalent to that of group 8 fish trawlers although this was not the case with the other variables. However, the variable means for groups 6 and 7 fish trawlers were estimated from very small samples with observations pre-dating the 1976 and 1979 diesel price increases. Trip receipt data for these groups were also available for only a few years. Consequently groups 6, 7 and 8 were treated as a single Class C for fish trawlers.

5.3.1 Horsepower Class Composition of Trawl Fleets

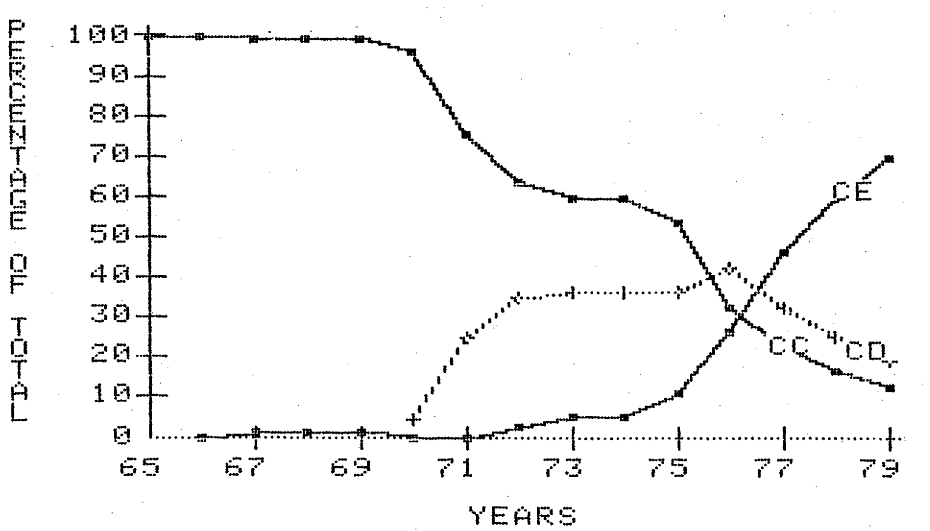
Figure 5.1 shows the expansion of the 3 fleets and Figures 5.2, 5.3 and 5.4 show the expansion of the horsepower class of the FT, PKT and SPT fleets, respectively, since 1965. The pattern of growth and adjustment of the fleets in these figures corresponds with the description of technological changes already adumbrated. The extremes in horsepower class composition and dominance in the three fleets are particularly noticeable. Since 1971 and the introduction of the high opening trawl, the FT fleet has shifted quickly to larger horsepower classes especially in Class E after 1975. In contrast nearly all growth in the SPT fleet since 1971 has been in Class A trawlers. It appears that the majority of the additional Class A small prawn trawlers in 1971-1979 were Class A small prawn trawlers because the other two fleets have only grown marginally in that period. The growth pattern of the PKT fleet is again different from either the FT or SPT fleets. Instead of a dominant horsepower class, the horsepower classes of the PKT fleet are more or less evenly divided among the 5 horsepower classes. These different patterns justify our treatment of the fleets as separate trawl types. Such an approach also has the

FIGURE 5.1: TOTAL TRAWL FLEET IN KEDAH/PERLIS BY TRAWL TYPE, 1965 - 1979



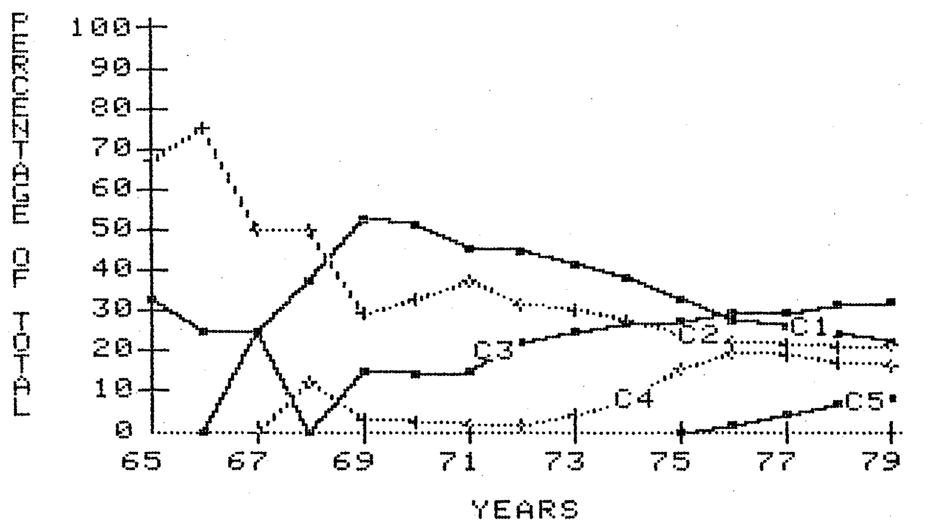
TF - Total Fleet
SPT - Small Prawn Trawlers
FT - Fish Trawlers
PKT - Pulau Ketam Trawlers

FIGURE 5.2: FT FLEET IN KEDAH/PERLIS BY HORSEPOWER CLASS, 1965 - 1979



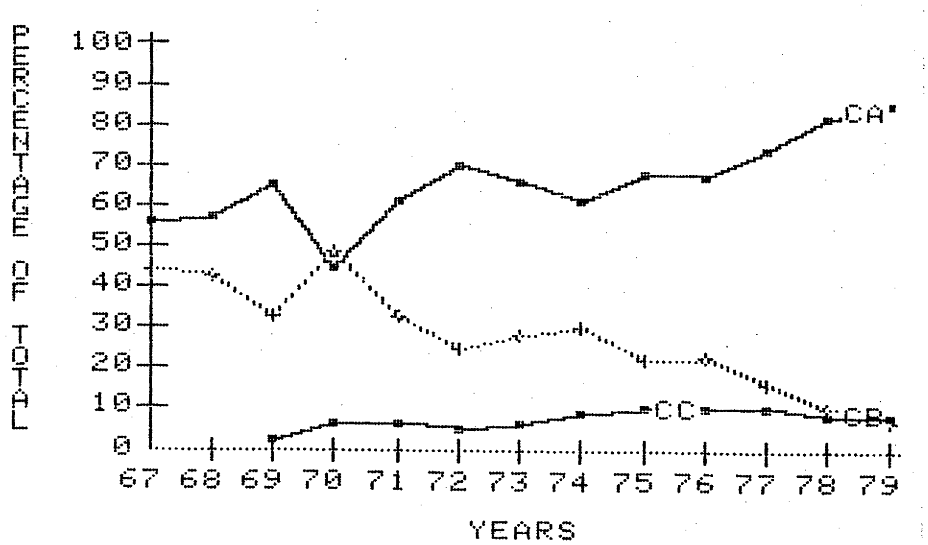
CC - Class C
CE - Class E
CD - Class D

FIGURE 5.3: PKT FLEET IN KEDAH/PERLIS BY HORSEPOWER CLASS
1965 - 1979



C1 - Class A
C2 - Class B
C3 - Class C
C4 - Class D
C5 - Class E

FIGURE 5.4: SPT FLEET IN KEDAH/PERLIS BY HORSEPOWER CLASS
1967 - 1979



CA - Class A
CB - Class B
CC - Class C

advantage of highlighting the obvious differences among the three trawl types in the factors governing their choice of technology and future trends in fishing effort [see chapter 8].

5.3.2 Vessel-Gear Types

Accurate categorisation of a heterogeneous fishing fleet for the purpose of estimating effective fishing effort, also requires that each category represents homogeneous catchability coefficient. The catchability coefficient in the fisheries concerned is largely determined by the net dimension and the manner in which it is employed. The SPT and PKT fleets use the same type of prawn trawl. It can be assumed that purse seine vessels, at least those still in operation, used nets with similar catchability. The FT fleet on the other hand used three different types of net, namely the prawn trawl, Thai trawl and high opening trawl, which cannot be assumed to have the same catchability. The aggregate trawler and purse seine fleets are therefore subdivided according to, first, fishing unit type, second, horsepower class, and finally, net type. This system of classification results in 16 vessel-gear types, 3 SPT types, 4 PKT types, 8 FT types and 1 purse seine type (see Table 5.6).

5.4 Fishing Grounds and Nominal Effort

5.4.1 Total Fishing Area

Parties interviewed in the field consistently maintained that by 1969, the coverage of the trawl fleets had extended over the total feasible trawling area off Kedah/Perlis. This seems reasonable in view of the small size of the total trawlable area in relation to trawl numbers and the concentration of commercial species along its

TABLE 5.6 : CLASSIFICATION OF THE AGGREGATE TRAWLER AND PURSE SEINE FLEETS

Fishing Unit Type	H.P. Class	Net Type	Vessel-gear code
1. Small Prawn Trawler	A	Prawn Net	113
2. "	B	"	123
3. "	C	"	133
4. Pulau Ketam Trawler	A	"	213
5. "	B	"	223
6. "	C	"	233
7. "	D	"	243
8. "	E	"	253
9. Fish Trawler	C	High Opening Net	332
10. "	D	"	342
11. "	E	"	352
12. "	C	Thai Trawl Net	331
13. "	C	Prawn Net	333
14. "	D	"	343
15. "	E	"	353
16. Purse Seine	C	Purse Seine	434

outer margins. The feasible trawling area is circumscribed by the Thai border and Langkawi Island in the north, Penang in the south and a large muddy area unsuitable for trawling covering the area between the 45 - 70 meters and stretching from just south of Langkawi Island to the southern border (see Figure 5.5). The resultant trawling area approximates 1725 sq.nautical miles [Lam et.al,1975,p.7]. By 1969 there was already an average of 0.16 active trawler per square nautical mile. Although trawl density had increased to 0.57 trawler per sq. nautical mile by 1979, the trawl density in 1969 would seem sufficient to elicit expansion of the total area covered. All trawl surveys to date in Kedah/Perlis waters [Md. Shaari et.al,1974; Lam, et. al, 1975; Md. Shaari et.al, 1976] have found the commercial species to be concentrated in a band between depths of 20 - 50 meters; the total catch rate decreasing sharply in deeper and shallower waters. In other words the bulk of the commercial species is concentrated in the outer limits of the trawlable area. The trawlers, in particular the fish trawlers, would certainly have at a very early date concentrated their efforts in this area. The operating range of the purse seine fleet is more problematic. The search of surface schooling fish tended to produce a higher propensity for geographic expansion of the total fishing area. The gear is not adversely affected by the condition of the sea bottom or obstacles therein and the fishing power of the vessel does not necessarily decrease with depth. The long history of the fleet in Kedah/Perlis and the absence of new technological development since 1969 suggest that by 1969 most feasible fishing grounds would have been discovered and probed especially when it is borne in mind that the target species, the Kembong, concentrate in depths of 30 - 40

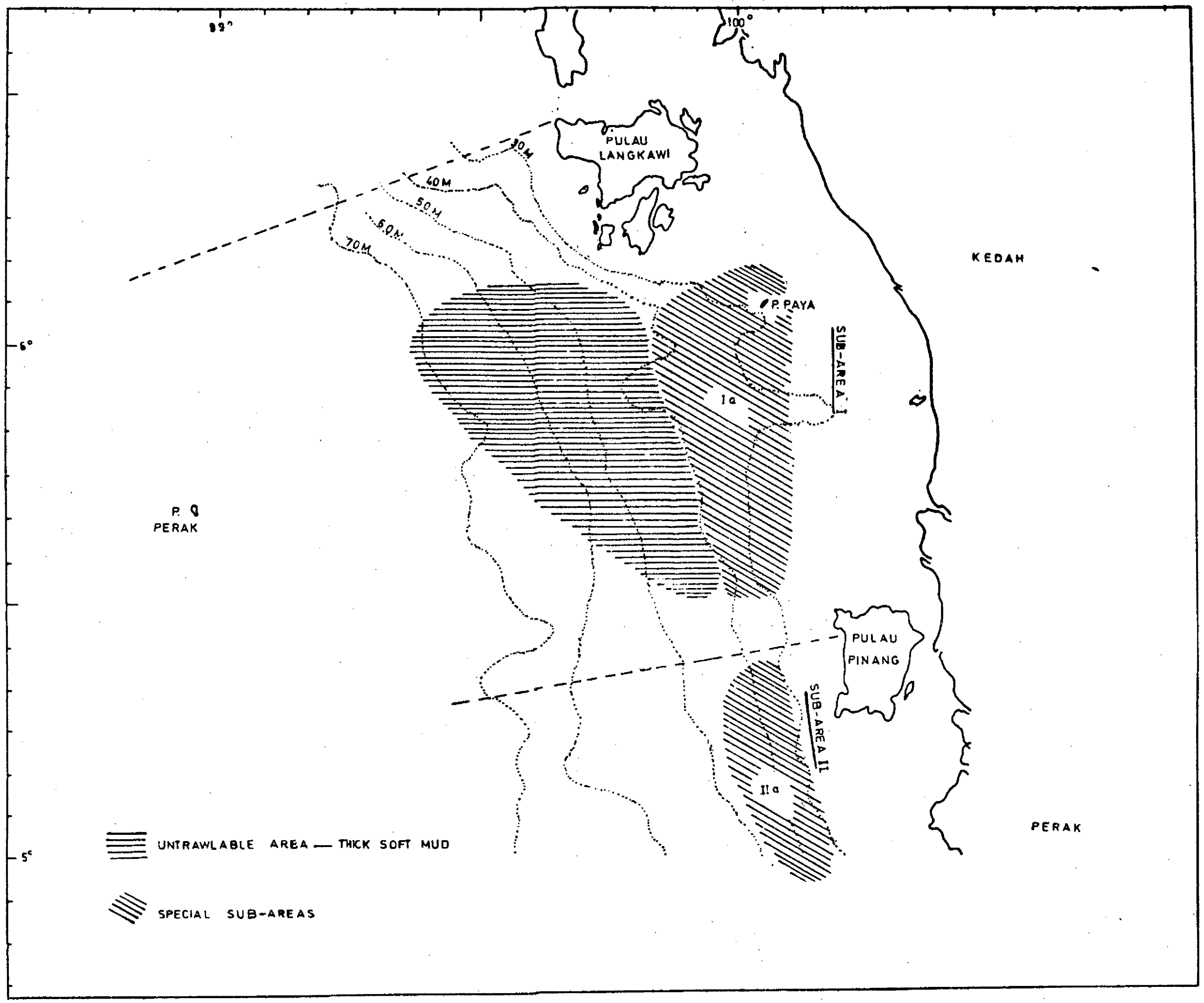


Fig. 5.5 *Chart indicating sub-areas, special sub-areas and untrawlable area of thick, soft mud.*

Source: Mohammad Shaari and Chai, 1976, p.15.

meters. Nevertheless, the searching or prowling practice of the purse seine fleet and increased competition from fish trawlers may still have led to the discovery and exploitation of new grounds and the expansion of total fishing area.

5.4.2 Trawl Grounds

The fish stock exploited by the trawl fleets is not distributed homogeneously over the total trawl area but appears to be concentrated in three areas. The three fish trawl surveys conducted by the Fisheries Division found the demersal and semi-pelagic stocks to be concentrated in a belt along the eastern edge of the muddy, untrawlable area. The prawn trawl survey of 1976, identified two areas of high prawn density: just south west of Langkawi Island and the area centered on the 20 meter line stretching from Kuala Sanglang to Tanjong Dawai. Discussions with concerned parties and information from the fishing effort survey enabled us to identify the grounds preferred by each fleet. The fish trawlers naturally focused their fishing activities in the fish grounds. This diagnosis is confirmed by the average distance from shore, steaming time and depth reported by fish trawl owners in Table 5.7. Both the PKT fleet and the fish trawlers when using a prawn net seem to operate primarily in the prawn grounds south-west of Langkawi Island. However, the PKT fleet has a greater average steaming time, a greater coefficient of variation and operates closer to shore than the fish trawlers. These imply that the FT fleet's prawn net effort is concentrated in the southern reaches of the grounds and the PKT fleet in the northern reaches. This distribution of effort is probably related to the prohibition of the operation of 30 ton vessels within 7 miles of shore. FT vessel owners have admitted from Table 5.7, that they often operate both prawn and fish nets within the 7 mile limit. However, they maintained that the extent to which they violate the prohibition is affected by the fact that the expected probability of capture decreases exponentially with distance from shore. The SPT fleet quite clearly specialises in the fishing ground which straddles the 20 meter line.

5.4.3 Unit of Nominal Effort

The appropriate measure of time from the perspective of population dynamics is the period during which the fishing vessel is actually sampling the fish populations. Sampling refers to the time spent searching for fish and operating the gear to catch the fish. The relative importance of these two components of productive fishing time differ significantly between trawler and purse seine units. The trawlers, none of which use electronic fish finders, do not spend time looking for fish. Decisions on the choice of fishing grounds are made before they go out to sea. Once at sea the trawlers proceed to the grounds chosen and drop their nets. In contrast, the purse seine units spend most of their time at sea searching for fish schools and productive fishing spots. The use of the lure and lamp rafts decreased search time to some extent but as only pukat jerut malam units are now operated, search time remains a major component of actual fishing time.

In this study the most accurate measure of nominal fishing effort is the number of days fishing. However, there are two primary sources of bias in using days fishing as a measure of nominal effort: 1) variations in the composition of time spent at sea between trawl types, and 2) changes in actual fishing time over the years.

TABLE 5.7 : COMPOSITION OF TIME SPENT AT SEA

	Distance fr. shore (mls.)	Steaming time (hrs.)	Time actually fishing (hrs.)	Hauls per day	Hours per haul	Total time at sea (hr.)	Depth meters	No. of observ.	No. of day/trip
Fish Trawlers									
1. using fish net									
a) mean	6.99	5.75	9.08	3.02	3.01	15.57	31.09	77	1
b) coefficient of variation	10%	22%	4%	3%	2%	10%	13%		
2. using prawn net									
a) mean	5.26	4.63	8.66	1.98	4.54	15.70	24.22	46	1
b) coefficient of variation	0.23%	0.25%	0.14%	0.2%	0.25%	0.2%	0.15%		
Small Prawn Trawlers									
using prawn net									
a) mean	3	3	8.1	2	4	12.1	18.29	40	1
b) coefficient of variation	1%	2%	6%	8%	1%	4%	2%		
Pulau Ketam Trawlers									
using prawn net									
a) mean	4.4	6.2	8.5	2	4.2	15.6	14.33	104	3.9
b) coefficient of variation	29%	17%	15%	7%	8%	14%	21%		

Source: Fishing Effort Survey (QUES.11)

In the survey of fishing effort, information on the composition of time spent at sea was obtained from owners of trawl vessels. The findings in Table 5.7 clearly shows that despite differences in steaming time, number of hauls per day, number of hours per haul and number of days per trip, all trawler types trawled the same number of hours per day. Each trawl type also has a rather small coefficient of variation in number of hours actually fished per day at sea. The homogeneous pattern of operation exhibited by the three trawl types is evident in Table 5.7. The mean number of hauls per day and hours per haul for each trawl type has a small coefficient of variation. The fish trawlers when using a fish trawl attempt to carry out three hauls per day at three hours per haul. All trawl types when using a prawn net planned two hauls at four hours per haul for each day at sea. It must be noted here that Table 5.7 refers to the average planned operating pattern and not the average pattern actually carried out.

According to the market agents and vessel owners, the daily operating pattern of trawlers using prawn nets has remained unchanged since 1969 whereas the fish trawlers have increased the number of hours per haul. Prior to 1969 fish trawlers using the Thai trawl engaged in three two-hour hauls per day. After 1969 they began adopting the present pattern of three three-hour hauls which by 1974 was the norm. As has been noted earlier, the conversion from the Thai trawl to the high opening trawl coincided interestingly with the practice of increased actual fishing time. This suggests that both processes were directly related in that the larger Class D engines associated with the high opening nets decreased steaming time hence permitting more actual fishing time and were perhaps triggered off by the common need to maintain catch rates. In the absence of information which enables us to do otherwise, it will be assumed that the two processes had the same growth rate as the Class D trawlers from 1969 to 1974. Figure 5.6 shows the cumulative growth curve of Class D trawlers and the set of multipliers derived therefrom and used to correct the increase in actual fishing time per day is given in Table 5.8.

5.4.4 Nominal Effort of Trawl Fleets

The average monthly days fishing and months fishing per year per fish trawler, and per vessel gear-type as calculated from panggu and trip receipt records are given in Table 5.9.

The results reveal five major points pertinent to the economic and biological modelling process. They are set out as follows: 1. The estimates from the panggu and trip receipt records are all statistically equivalent to a 1% level of significance.

2. The average number of days fishing per month and months fishing per year of the FT fleet have not changed essentially between 1969 and 1979; the averages for the whole period being 20.9 days and 11.4 months respectively, confirming the results of the input correlation matrix.

3. The input correlation matrix (Table 5.1) indicates no significant degree of correlation between engine horsepower and the annual rate of nominal fishing effort. Table 5.9, however, clearly shows that since 1975 at least, the average annual days fishing per month in the FT fleet has increased the higher the horsepower class. The average annual number of months fishing per year did not.

4. The average annual effort rate of Class C fish trawlers has

FIGURE 5.6: GROWTH CURVE OF CLASS D FT VESSELS
1969 - 1974

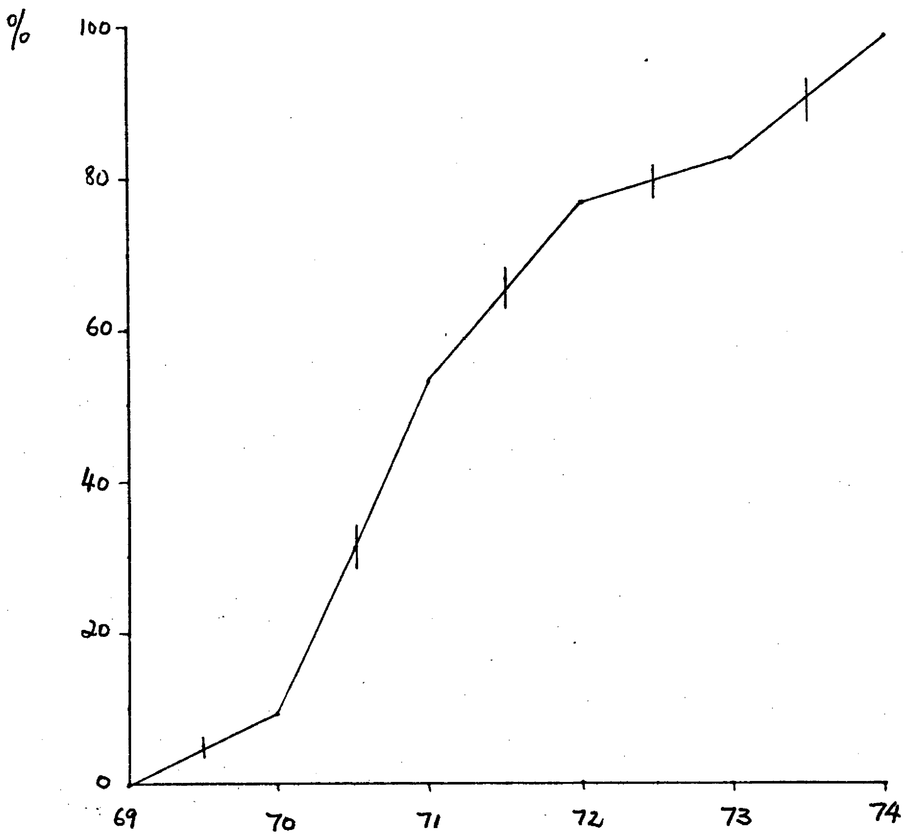


TABLE 5.8: CORRECTIONS OR CHANGES IN ACTUAL FISHING TIME PER DAY (NOMINAL EFFORT) IN VESSEL-GEAR TYPES USING FISH TRAWL

	Corrections
1969	0.66
1970	0.77
1971	0.89
1972	0.93
1973	0.97
1974-	
1979	1.00

TABLE 5.9

AVERAGE ANNUAL NUMBER OF DAYS FISHING PER MONTH BY FISH TRAWLERS USING A FISH TRAWL, A PRAWN TRAWL AND EITHER NET FROM TRIP RECEIPT RECORDS AND THE AVERAGE ANNUAL NUMBER OF DAYS FISHING PER MONTH AND MONTHS FISHING PER YEAR FROM PANGGU RECORDS FOR EACH CLASS AND ALL CLASSES

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Yearly av.	% of c
I. Class C													
1. Trip Receipt Records													
a) fish net	7.3	n.a.	n.a.	n.a.	16	17.5	16.7	16.7	16	15	n.a.	13.3	65
b) prawn net	13.6	n.a.	n.a.	n.a.	5.1	3.9	4	4	2.1	3.9	n.a.	7.3	35
c) fish or prawn net	20.9	n.a.	n.a.	n.a.	21.1	21.4	20.7	20.7	18.1	18.9	n.a.	20.6	100
d) no. of observations	14	0	0	0	11	7	8	2	1	1	0	44	
2. Panggu Records													
a) fish or prawn net	20.9	20.4	19.6	19.6	21.9	21.7	20.8	19.9	17.8	18.1	15.9	20.3	99 [1]
b) no. months fishing/yr.	11.8	10.3	12	11	11.6	11.5	11.3	10.9	10.5	10.8	10	11.2**	-
c) no. of observations	9	11	12	12	11	6	6	4	3	3	1	78	-
II. Class D													
1. Trip Receipt Records													
a) fish net	-	n.a.	n.a.	n.a.	12.7	15.9	19.9	20	17.6	18.8	18	17.7	86
b) prawn net	-	n.a.	n.a.	n.a.	8	4.8	1.2	1.1	1.9	1.9	1.9	2.8	14
c) fish or prawn net	-	n.a.	n.a.	n.a.	20.7	20.7	21.2	21.1	19.5	20.7	19.9	20.5	100
d) no. of observations	-	0	0	0	8	8	8	12	12	10	5	63	-
2. Panggu Records													
a) fish or prawn net	-	20.1	21.9	21.7	20.7	20.7	21.2	21.6	19.5	20.6	19.9	20.9	102
b) no. months fishing/yr.	-	11	10.9	10.6	11.7	11.8	11.6	11.5	11.6	11.4	10.9	11.5**	-
c) no. of observations	-	1	3	5	8	14	19	17	8	6	4	85	-
III. Class E													
1. Trip Receipt Records													
a) fish net	-	-	n.a.	n.a.	n.a.	n.a.	18.8	20.2	20.5	20	19.6	19.8	93
b) prawn net	-	-	n.a.	n.a.	n.a.	n.a.	3.4	1.7	1	0.8	1	1.5	7
c) fish or prawn net	-	-	n.a.	n.a.	n.a.	n.a.	22.2	22.4	21.5	20.8	20.6	21.3	100
d) no. of observations	-	-	0	0	0	0	5	7	7	7	15	41	-
2. Panggu Records													
a) fish or prawn net	-	-	n.a.	n.a.	n.a.	22.1	22.2	22.2	21.5	20.7	20.4	21.3	100
b) no. months fishing /yr.	-	-	n.a.	n.a.	n.a.	11	11.9	11.5	11.6	11.8	10.7	11.4**	-
c) no. of observations	-	-	0	0	0	2	8	20	20	22	19	91	-
IV. All Classes													
1. Trip Receipt Records													
a) fish net	7.3	n.a.	n.a.	n.a.	14.6	16.6	18.4	19.8	18.5	19.1	19.2	17	82
b) prawn net	13.6	n.a.	n.a.	n.a.	6.3	4.4	2.8	1.7	1.6	1.5	1.2	3.8	18
c) fish or prawn net	20.9	n.a.	n.a.	n.a.	20.9	21	21.2	21.5	20.1	20.6	20.4	20.8	100
d) no. of observations	14	n.a.	n.a.	n.a.	19	15	21	21	20	18	20	148	-
2. Panggu Records													
a) fish or prawn net	20.9	20.4	20.1	20.2	21.4	21.1	21.4	21.7	20.6	20.4	20.1	20.9	100
b) no. months fishing/yr.	11.8	10.4	11.8	10.9	11.6	11.6	11.6	11.4	11.5	11.6	10.7	11.4**	-
c) no. of observations	9	12	15	17	19	22	33	41	31	31	24	254	-

Source: Panggu and Trip Receipt Records

** Not statistically different from 12 at a 5% level of confidence.
n.a. = not available.
[1] Average number of days at sea from Panggu Records as a percentage of that from Trip Receipt Records.

declined sharply since 1975. The average annual days fishing per month declined from 20.9 in 1975 to 15.9 in 1979 while months fishing per year declined from 11.8 to 10.0 during the same period. Neither of the larger horsepower classes exhibited similar trends. The decline in the effort rate coincided with the rapid decline in Class C numbers (see Figure 5.2) probably because the Class C trawlers became increasingly obsolete and less competitive leading to difficulty in maintaining crews of adequate size and quality [2].

5. The decline in the relative use of the prawn net by the FT fleet is the most important disclosure of Table 5.9. In 1969 the FT fleet on the average used the prawn net on 13.6 out of 20.9 days per month or for 65% of the time. [The panggu estimate is used here because of its continuity throughout the 1969-1979 period.] In stark contrast, the prawn net was used in 1979 on only 1.2 out of 20 days or for 6% of the time. The conversion from the Thai trawl to the high opening trawl undoubtedly accounted much for the trend. An implication that arises is that, in 1969 at least, the FT vessels were primarily prawners which occasionally used the Thai net. The high opening net which facilitated access to the rich semi-pelagic stocks had enhanced the relative profitability of fish trawling such that the relative use of the prawn net in all three horsepower classes decreased continuously between 1973 and 1979. In the large horsepower classes the ratio of fish trawl use to prawn trawl use became larger each

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[2] 1979 was a bad year with respect to nominal fishing effort because of the diesel shortage from June to September which forced many trawlers to tie up or to use a prawn net to minimise fuel consumption.

year so that by 1979 the Class E trawlers used the prawn net on an average of 1.0 out of 20.8 days fishing per month.

Except for Class A trawlers of both prawn trawl types, the SPT and PKT fleets, in the short period for which records were available, have in general averaged the same number of days fishing per month and months fishing per year as the FT fleet (Table 5.10). While the Class A vessels averaged the same number of months fishing per year, they averaged only 16.8 and 19.0 days fishing per month in the SPT and PKT fleets respectively. The performance of this class of vessels was particularly low for both prawn trawl fleets in 1979 and declined continuously during 1975-1979 for the SPT fleet, a result which conflicts with the insignificant correlation between time and horsepower in both prawn trawl classes in Table 5.2. This apparent contradiction can be explained by the very small total variation in horsepower size in the SPT fleet, the relatively small number of Class A vessels in the PKT fleet, and the diesel shortage which limited fishing days. However, it does illustrate that Class A vessels have a lower rate of effort than vessels in the larger horsepower classes.

5.5 The Treatment of Multiple Outputs

5.5.1 Taxa Identified

The trip receipts obtained from the fish trawl owners and SPT market agents had up to 50 different categories of catch: 41 fish, 3 cephlopods, 4 prawns and 2 brachiopods. The categorisation is for the purpose of sorting out the catch into types with different market prices. Fortunately, the Malaysian fresh fish market is very articulate with all but the most similar species having individual

TABLE 5.10
AVERAGE ANNUAL NUMBER OF DAYS FISHING PER MONTH AND MONTHS FISHING PER YEAR FOR SMALL PRAWN TRAWLERS AND PULAU KETAM TRAWLERS BY CLASS FROM 1975 TO 1979

	1975	1976	1977	1978	1979	Annual Tot.[1]
I. Small Prawn Trawlers						
1.Class A						
a) av. no. days fishing	19.1	19.2	19.3	17.7	15.3	16.8
b) no. months fishing	10.3	11.2	11	12	11.5	11.3
c) no. of observations	10	17	21	17	15	80
2. Class C [2]						
a) av. no. days fishing	n.a.	22.8	19.5	19.9	n.a.	20.5
b) no. months fishing	n.a.	10.3	12	11.9	n.a.	11.5**
c) no. of observations	0	3	4	5	0	12
II. Pulau Ketam Trawlers [3]						
1. Class A						
a) av. no. days fishing	20.7	20.4	18.9	19	16.6	19
b) no. months fishing	10	11.6	11.3	10.8	10.9	11
c) no. of observations	4	5	8	8	5	30
2. Class B						
a) av. no. days fishing	22.3	23.2	20.4	19.7	19	20.6
b) no. months fishing	10	11.6	11.9	11.6	10.9	11.5**
c) no. of observations	1	9	10	10	10	40
3. Class C						
a) av. no. days fishing	22.5	23.7	19.7	19.6	18.4	19.8
b) no. months fishing	11.6	11.8	11.7	11.7	11	11.5**
c) no. of observations	1	6	18	21	15	61
4.Class D						
a) av. no. days fishing	n.a.	24.7	20.4	20.3	19.8	20.9
b) no. months fishing	n.a.	12	11.3	11.6	11.8	11.6*
c) no. of observations	0	7	17	14	11	49
5. Class E						
a) av. no. days fishing	_	24.3	19.9	20.9	19.6	20.6
b) no. months fishing	_	12	11.5	11.3	11.7	11.5*
c) no. of observations	_	1	3	6	4	14

Source: Panggu Records

[1] The hypothesis that the reported mean months fishing per year is equivalent to 12 is accepted at a * - 10% level of confidence and a ** - 5% level of confidence.
[2] There is no record for Class B Small Prawn Trawlers.
[3] Only those trawlers which operated at least 6 months in a given year are selected to avoid double counting replacement vessels.

market prices. As a result the 50 categories recorded in the trip receipts also represent biological groupings. However, because of the large number of species caught and the low catch rates of some species, the categories are usually aggregations of a number of similar species albeit at times with quite different biological characteristics.

In order to reduce the number of decision variables, the various categories had to be combined quite apart from the existing aggregations. This was accomplished by aggregating all fish and cephalopod categories by family and all prawn and brachiopod categories by order which also meant aggregating all size classifications within each recorded category. This method of classification which enabled the number of taxa to be reduced to 31 also has the advantage of a sound biological basis. It is employed by the Malaysian and Thai fisheries statistics, and the selected taxa are relatively homogeneous with respect to prices.

Three fish types, Sharks, Catfishes and Rays, were aggregated at order level in the trip receipt records which precluded classification at the family level. A broader grouping for them was used because a large range of species was caught, at low rates, and they fetched relatively similar prices. But the component species of these taxa differ markedly in their habitats. Each of the three taxa is composed of estuarine, demersal and semi-pelagic species. Their ecological heterogeneity will seriously hinder any estimation of their relative abundance and surplus production. However, none of these taxa is of relative importance in terms of value or weight.

In the cases of Carangidae and Prawns, reported categories with diverse habitats and prices were aggregated in the classification.

The Carangidae taxa consists of eight reported categories, two demersal and six semi-pelagic. However, during the 1973-1979 period over 80% of the total Carangidae catch of the sampled trawlers was composed of semi-pelagic species. The dominance of semi-pelagic species was deemed to justify the aggregation of all Carangidae categories. The trip receipts classified all prawn species harvested into four categories: 1. Tiger prawns, 2. Banana prawns, 3. Pink prawns, and 4. Sand Prawns. These are the four main prawn groups harvested by the trawlers in Kedah/Perlis (see Table 2, Appendix C, for groupings of major prawn species caught in Malaysian waters). Other types of prawns landed are grouped with the Pink prawns. The four reported prawn groupings are listed above in order of their economic value. For example, ex-vessel prices ranged from \$5.50 to \$12.50 per kati and \$0.70 to \$0.85 per kati in 1979 for Tiger and Sand prawns respectively. The average size and catch rates of the prawn species were inversely proportional to their relative economic value. As has been explained at the outset, it was decided to aggregate the four reported prawn categories inspite of the substantial differences in their prices, size and probable surplus production, in order to limit the number of decision variables.

5.5.2 Taxa Classified by Community and Trophic Level

For expositional purposes, the selected taxa were classified by community type and trophic level. The inshore ecosystem off Kedah/Perlis can be roughly divided into two general community types, on the basis of the type of substrata and the depth inhabited, into demersal and semi-pelagic. Each community type can be subdivided into 3 to 6 trophic levels according to its position in the food chain. The selected taxa by community type and trophic level is given in Table 5.11.

5.6 Catch Per Unit Effort

It will be noted that the absolute and relative growth patterns of the three trawl types described in Figure 5.1 exhibit three characteristics pertinent to the estimation of catch per unit of effort. First the rapid growth rate of the SPT fleet relative to the FT and PKT fleets resulted in the domination of the industry, in terms of numbers of vessels, by the small prawn trawlers. The SPT fleet accounted for 63% of the total active trawlers in 1979 as compared to a mere 24% and 13% share by the FT and PKT fleets respectively. The fish trawlers, which are the largest, thus constitute a minor and decreasing part of the combined trawl fleet. This means that the major part of unstandardised effort is exerted on fish populations exploited by small prawn trawlers.

Second, the rapid growth of the SPT fleet and the corresponding increase in total prawn effort, make it difficult to assume as does the Schaefer and Fox model, that the populations, (at least the longer living ones) are in a state of equilibrium. Although the Gulland-moving model can be used for non-equilibrium populations, the availability of data as will be seen later, limits the averaging period and our ability to model adequately long living populations in non-equilibrium conditions, (see Chapter 6).

Third, the marked stability of the FT fleet, particularly since 1971, in terms of trawler numbers, implies stability of effective effort on populations primarily exploited by the fish trawler and this in turn suggests approximation to equilibrium conditions.

TABLE 5.11
ESTIMATED CATCH BY COMMUNITY, TROPHIC LEVEL AND TAXA OF ALL TRAWL TYPES IN KEDAH/PERLIS (IN METRIC TONNES)

		1975	1976	1977	1978
I. Demersal		10726	13614	17225	16208
A. Zoobenthic Prey		2879	4666	5263	4993
Prawns	3	2878	4666	5263	4993
B. Large Zoobenthic Feeders		456	491	309	385
Rays	17	456	491	309	385
C. Brachyura	15	515	396	531	362
D. Prey Fishes		2390	3496	5366	5325
1(a) Gerridae	6	733	1516	2354	1708
(b) Nemipteridae	7	742	1170	1632	2324
2. Flatfishes	11	846	749	1329	1095
3(a) Mullidae	26	46	46	27	85
(b) Leiognathidae	27	23	15	24	23
E. Intermediate Predators		4206	4221	5421	5224
1(a) Scianidae	8	1006	958	1654	1906
(b) Bramidae	19	348	189	226	220
(c) Ariidae	22	110	61	153	142
(d) Pomadasyidae	24	87	73	108	88
(e) Lutjanidae	25	131	50	66	76
2. Sepioidea	4	2033	2311	2289	1807
3(a) Sphyraenidae	14	367	402	701	780
(b) Sharks	21	121	150	203	188
(c) Drepanidae	29	3	27	21	17
F. Large Predators		271	344	335	419
1. Serranidae	20	184	229	232	320
2. Muraenesoadae	23	87	115	103	99
II. Semi-Pelagic		15719	18480	16365	18036
G. Prey		8803	11286	8279	9264
1(a) Kembong	1	7591	9300	5983	6657
(b) Clupeidae	5	908	1642	1879	2004
2(a) Dorosomidae	18	295	326	398	579
(b) Engraulidae	28	9	18	19	24
H. Intermediate Predators		5723	5566	5743	6051
1. Loligoidea	2	4864	4553	4509	3953
2. Carangidae	10	859	1013	1234	2098
I. Large Predators		1193	1628	2343	2721
1(a) Chirocentridae	13	671	976	757	791
(b) Rachycentridae	30	5	12	10.8	14
2(a) Trichiuridae	12	200	172	1176	1323
(b) Scomberomoridae	16	317	468	399	593
III. Misc. Catch	9	1400	1501	1393	1158
IV. Pooled Spp.	31	27836	33595	34983	35902

The main purpose of calculating CPUE is to estimate the amount of surplus production available from the populations at alternative levels of economic activity. The economic decisions governing the level of economic activity are primarily medium to long term in nature, for instance the choice of technology or capital and the biological processes determining the adjustment of the populations to such activity. The basic unit of time used in the analysis should therefore be of sufficient duration to allow the medium to long term decisions and processes to take place. Since at least a year is necessary, annual rather than monthly estimates of CPUE are desirable

Although the trip receipt records made it possible to estimate the catch per unit effort (CPUE) of trawl and purse seine vessel-gear types, the limited coverage of the trip receipt sample precludes the estimation of the CPUE of all PKT and Classes B and C SPT vessel-gear types. Moreover, the sample only covers the 1973-1979 period which is too short a time span for the purpose of calculating surplus production functions and must be supplemented by trawl survey and co-operative records.

The annual CPUE were estimated by a two-stage process which facilitates adjustments for unequal monthly sample size. First monthly CPUE were calculated using a ratio of the means estimator. The ratio of the means was used rather than the mean of the ratio because the variance of catch per taxon amongst the sampled trawlers was larger than the variance in nominal effort [Draper and Smith, 1966]. Secondly, since a number of sampled units did not have trip receipts for all months fished in a given year, it was often not possible to obtain a uniform sample size and composition for that given year. To overcome the variation in monthly sample size and to account for changes in monthly rate of nominal effort, it was decided to calculate annual CPUE by a ratio of means weighed by nominal effort. More specifically,

$$CPUE_{jk} = \frac{\sum_{i}^{12} \left(E_{ijk} * CPUE_{ijk} \right)}{\sum_{i}^{12} \left(E_{ijk} \right)}$$

where :

$CPUE_{jk}$ = annual catch per unit effort,

E_{ijk} = average nominal effort,

i = month,

j = taxa,

and, k = vessel-gear type.

The $CPUE_{jk}$ so estimated are given in Tables 3A - C, Appendix C.

In addition to the poor coverage of prawn trawl vessel-gear types, the small absolute size of the trip receipt sample was a problem. Only a 25% sample of all daily trip receipts could be recorded and since the use of the prawn net had decreased to an average of only a few days per month after the introduction of the high opening trawl, the sample size of FT vessel-gear types using a prawn net is necessarily small. This small sample size further increases the probability of sampling error. Regrettably, the absence of trip receipt records for the larger prawn trawlers not only prevented the verification of the accuracy of the estimated CPUE of FT-prawn net vessel-gear types, but also compelled reliance on them for the estimation of prawn net effort.

5.6.2 Estimating Annual Catch of Each Taxon

The annual catches of each taxon and vessel-gear type were calculated with estimates of CPUE, nominal effort and number of operating vessels. The estimates of annual catch per taxon were calculated by multiplying CPUE by its respective average days fishing per month, average months fishing per year and the number of operating trawlers. The annual catch per taxon of vessel-gear types for which trip receipt records were not available were estimated by using the CPUE of a vessel-gear type of the same vessel class adjusted as far as possible for differences in performance. The catch of Class A Pulau Ketam trawlers (vessel-gear type 213) was estimated with the CPUE of Class A small prawn trawlers (vessel-gear type 113) adjusted by the ratio of their average annual revenue per day, A^{i}_{213}

The adjustment factor A^{i}_{213} was calculated by

$$A^{i}_{213} = REV^{i}_{213} \;/\; REV^{i}_{113}$$

where :

REV^{i}_{213} = average revenue per day fishing for vessel-gear type 213 in the ith year,

REV^{i}_{113} = average revenue per day fishing for vessel-gear type 113 in the ith year.

The catch per taxon for Class B Pulau Ketam and small prawn trawlers, vessel-gear types 223 and 123 respectively were also estimated with the adjusted CPUE of vessel-gear type 113. The adjustment factor for estimating the CPUE of vessel-gear type 223 was

$$A^{i}_{223} = REV^{i}_{223} \; / \; REV^{i}_{113}$$

where :

REV^{i}_{223} = average revenue per day at sea for vessel-gear type 223 in the ith year,

REV^{i}_{113} = average revenue per day at sea for vessel-gear type in the ith year.

Estimation of the CPUE of vessel-gear type 123 was complicated by the absence of revenue data. Consequently the adjustment factor based on the relationship between Class A and Class B Pulau Ketam trawlers had to be used. More precisely, the CPUE of vessel-gear type 113 adjusted by A^{i}_{123},

where

$$A^{i}_{123} = A^{i}_{223} \; / \; A^{i}_{213}.$$

For lack of alternative information the nominal effort of vessel-gear type 123 was assumed to be equivalent to vessel-gear type

223's nominal effort. The annual catch per taxon of Class C small prawn trawlers, i.e. vessel classes 133, and Classes C, D and E Pulau Ketam trawlers, vessel-gear types 233, 243 and 253 respectively, were estimated using the unadjusted CPUE of FT- prawn net vessel-gear types of the same vessel class; these are vessel-gear types 332, 342 and 352. As the revenue data for the FT fleet disregarded the type of net used and treated all trips in a given panggu period without distinction, it was not possible to obtain estimates of revenue per day fishing for vessel-gear types 333, 343 and 353, nor to measure the relative performance of the Class C small prawn trawlers and Classes C, D and E Pulau Ketam trawlers.

The small absolute and relative sample of prawn trawlers could lead to biased CPUE estimates. Moreover, the use of proxy CPUE for all PKT and some SPT vessel-gear types necessarily assumes that the latter vessel-gear types have identical prices and catch compositions as the former. This is an assumption that may well be invalid, and will probably result in the under-estimation of prawn catches.

5.6.3 Catch of Combined Trawler Fleet

The catch per taxon of the combined trawler fleet estimated from the trip receipt records for 1975 to 1978 is given in Table 5.11. Despite the shortcomings described above, these estimates should provide an indication of present size and composition of food fish production in the trawl industry even though the period covered by the records is short.

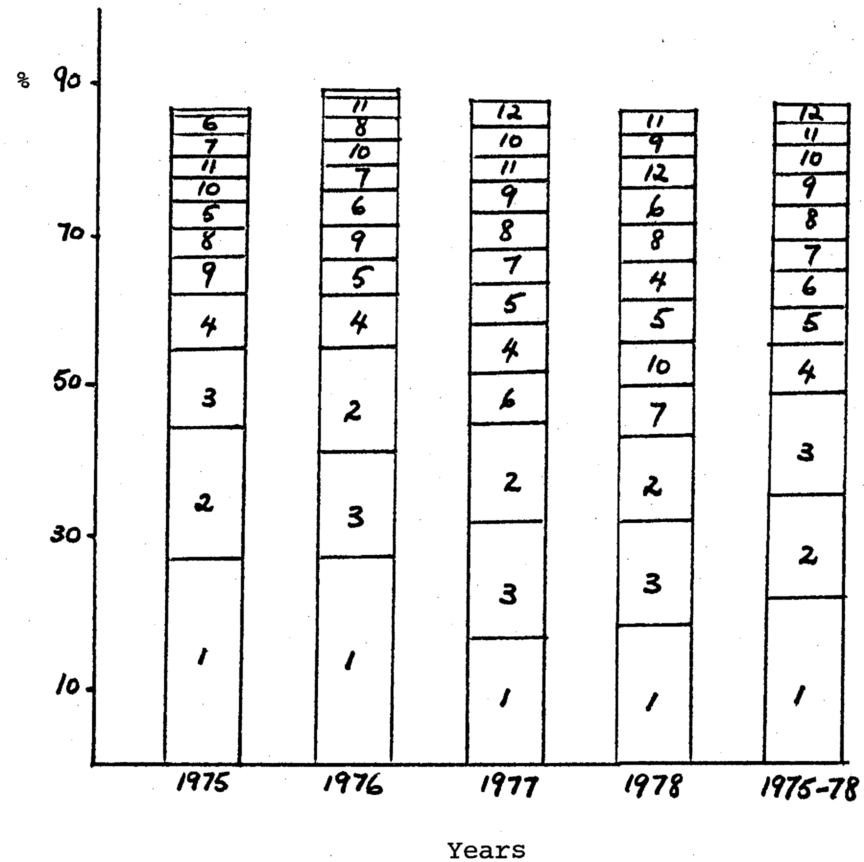
The total food fish harvest as estimated in this study has increased from 27836 metric tonnes in 1975 to 35902 metric tonnes in 1978 representing an average growth rate of approximately 10%. During the same period, the number of active trawlers of all types had increased at an almost identical rate of 11% per annum. Quite clearly the total catch per active trawler, the measure of relative abundance used in all studies to date on the Malaysian trawl fisheries, has on the average not displayed any significant trend. However, there have been significant fluctuations in total catch per active trawler (see Table 5.12).

The total catch of the combined trawler fleet has been dominated at least in the 1975-1978 period by 12 major taxa shown in Figure 5.7. These 12 taxa accounted for an average of 86% of the total catch with only minor variations in aggregate share. Nevertheless, there have been significant changes in their relative importance.

Throughout the 1975-1979 period, Kembong made up the largest share of total catch with an average of 22.3%. Loligoidea and Prawns were the second and third largest taxa each representing 13.5% of the total combined trawler catch. These are followed by, in order of their share of total catch aggregated over the 1975-1978 period, Sepioidea (6.4%), Clupeidae (4.9%), Gerridae (4.8%), Nemipteridae (4.4%), Scianidae (4.2%), Miscellaneous (4.1%), Carangidae (3.9%), Flatfishes (3.0%) and Trichiuridae (2.2%).

After 1976, the Kembong catch declined in both relative and absolute terms. However, this decline and to a lesser extent the decline in the Loligoidea catch were more than compensated by the absolute and relative increases in Nemipteridae, Gerridae, Carangidae and Trichiuridae catches. The rapid growth of these four taxa, of which only Carangidae yields a high price, is the first indication that they are strategist more able to withstand progressive fishing mortality. This will be substantiated in later discussion.

FIGURE 5.7: TOTAL TRAWL CATCH BY 12 MAJOR TAXA (1975 - 1978)



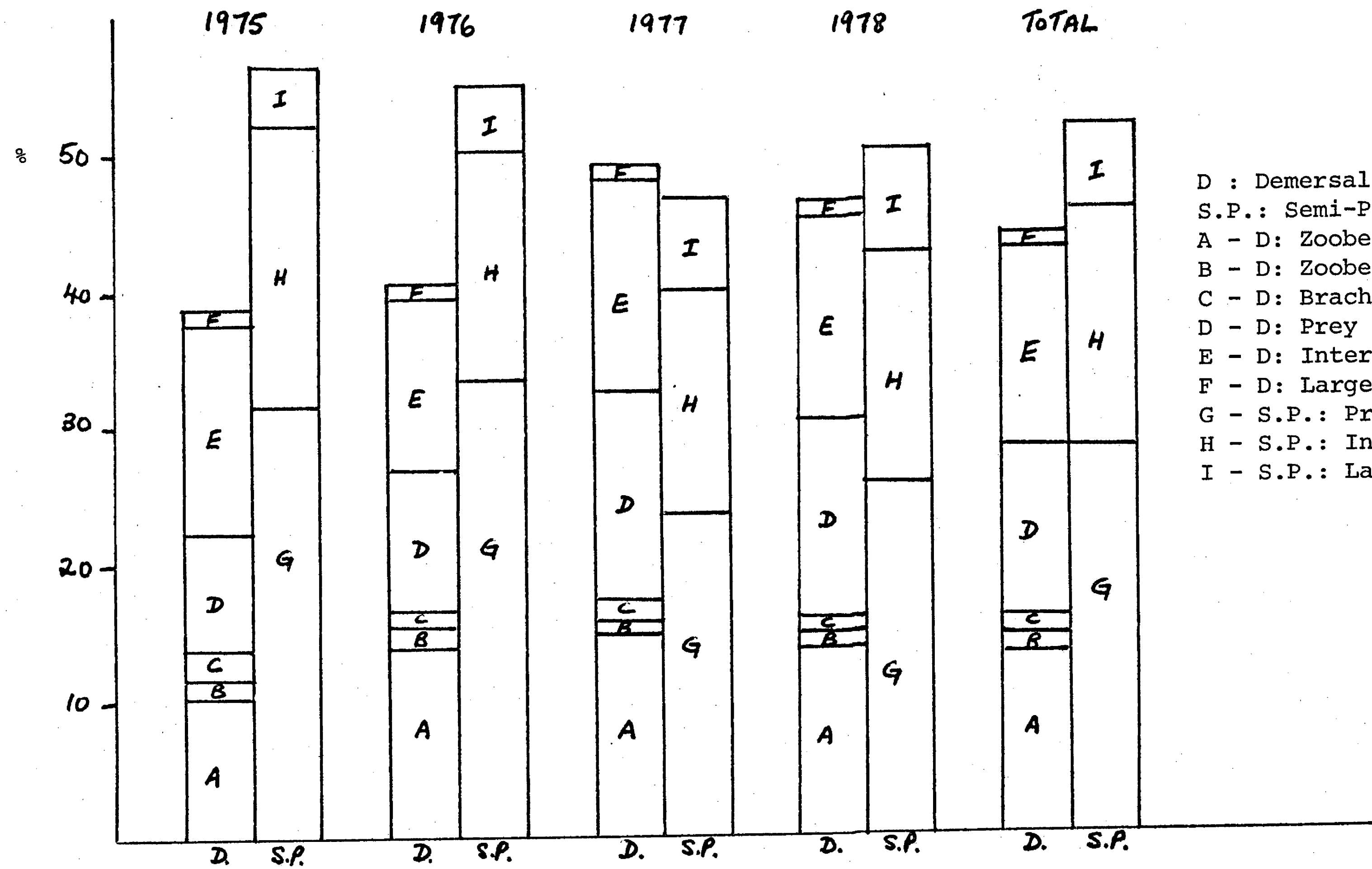
1. Kembong
2. Loligoidea
3. Prawns
4. Sepioidea
5. Clupeidae
7. Nemipteridae
8. Scianidae
9. Miscellaneous
10. Carangidae
11. Flatfishes
12. Trichiuridae

Two taxa exhibited a steady decline in relative share in the 1975-1978 period. They were Sepioidea and Miscellaneous catches. The absolute and relative decline of the latter is particularly noticeable and suggests a decline in infrequently caught species.

The most crucial point of Table 5.11 and illustrated in Figure 5.8 is that over half the total fish food production of the Kedah/Perlis trawl fishery is composed of semi-pelagic taxa. This is in sharp contrast to the trawl fisheries in other Malaysian states and neighbouring countries which harvest primarily demersal taxa [Pauly,1978; Gulland,1972; Annual Fisheries Statistics, 1979]. The use of the high opening trawl accounts for the high proportion of the semi-pelagic species in the combined trawl catch (see Table 5.13, Section B).

It also appears from Figure 5.8 that the trawl fishery has exerted a higher degree of fishing mortality on demersal predators than on demersal prey for the annual total catch of intermediate demersal predator is higher than that of demersal prey. Since the former necessarily has a lower abundance than the latter, the higher catch implies greater fishing effort on the predator taxa. The relatively high rate of fishing mortality on predator taxa will, ceterus paribus, reduce the natural mortality of prey taxa such that, theoretically at least, the biomass of prey taxa previously taken by predators is available to the fishery in the form of increased surplus production per level of fishing effort. The semi-pelagic community does not appear to be exploited in similarly disproportionate fashion. Semi-pelagic prey is on the whole the largest trophic level and is significantly larger than intermediate and large semi-pelagic predator trophic levels which are the third and sixth largest trophic levels in

FIGURE 5.8: TOTAL TRAWL CATCH BY COMMUNITY TYPES AND TROPHIC LEVELS



D : Demersal
S.P.: Semi-Pelagic
A - D: Zoobenthic Prey
B - D: Zoobenthic Feeders
C - D: Brachyura
D - D: Prey Fishes
E - D: Intermediate Predators
F - D: Large Predators
G - S.P.: Prey
H - S.P.: Intermediate Predators
I - S.P.: Large Predators

terms of total catch respectively. The catch of large and intermediate semi-pelagic predators is substantially greater than its demersal counterparts and has been increasing in relative terms.

5.6.4 Catch of Combined Trawler Fleet Compared with Estimates of the Fisheries Division

A comparison of the total catch of the combined trawler fleet as reported by the Fisheries Division, with the estimates of this study, substantially suggests that the rapid growth in total catch and catch per trawler reported by the Fisheries Division stemmed from its sampling method rather than actual changes in fish abundance. The reported total catch, as shown in Table 5.12, increased at an average annual rate of 40% per annum between 1975-1978 with particularly large increases between 1975 and 1976 and between 1976 and 1977. In contrast, only an average annual rate of 10% was recorded by this study. According to the Fisheries Division, the ratio of reported total catch to estimated total catch increased from 55% in 1975 to 71% in 1976 to near parity in 1977 and 1978. The discernible pattern of these estimates conforms to a practice of phasing in improved sampling techniques by the Fisheries Division, as described in Chapter 2.

An examination of the relative size of reported and estimated combined trawl catch by trophic level and community type also shows that the rapid relative growth of reported total catch can be attributed to improved sampling of the fish trawlers (Table 5.13). In 1975 the reported total catch of semi-pelagic taxa was only 28% of that estimated in this study; it increased to 37% in 1976, 98% in 1977, and 91% in 1978. In the case of demersal taxa, estimates of total catch by the Fisheries Division and in this study were

TABLE 5.12 : ESTIMATED TOTAL CATCH OF COMBINED TRAWL FLEET, ABSOLUTE AND RELATIVE TOTAL TRAWL CATCH ESTIMATED BY THE FISHERIES DIVISION AND TOTAL OPERATING TRALWERS

	1975	1976	1977	1978	Av. Rate Change
1. Estimated total catch (metric tons)	27836	33595	34983	35902	10%
2. Reported total catch (metric tons)	15322	23738	36017	33528	40%
3. % 2 of 1	55%	71%	103%	94%	24%
4. Total operating trawlers (no. units)	575	575	667	765	11%
5. Estimated catch per trawler (metric tons)	48.4	58.43	52.4	46.9	-

Source : Table 5.11, Annual Fisheries Statistics, 1976 - 1979 and Tables 3.2 to 3.4

TABLE 5.13 : SIZE OF TRAWL CATCH REPORTED BY THE FISHERIES DIVISION RELATIVE TO THAT ESTIMATED IN THIS STUDY FOR 1975 THROUGH 1978 AND PERCENTAGE OF ESTIMATED AGGREGATE TRAWL CATCH FOR THE 1975-1978 PERIOD ACCOUNTED FOR BY FISH TRAWLERS BY COMMUNITY AND TROPHIC LEVEL

	A				B
	1975	1976	1977	1978	1975 -78
I. Demersal	0.89	0.95	1.09	1.12	35
A. Zoobenthic Prey	1.26	1.14	1.67	1.71	6
B. Large Zoobenthic Feeders	0.27	0.20	0.38	0.42	32
C. Brachyura	1.14	1.26	1.17	1.29	21
D. Prey Fishes	0.72	0.58	0.82	0.79	46
E. Intermediate Predators	0.74	1.09	0.84	0.87	53
F. Large Predators	1.25	1.23	0.93	0.47	36
II. Semi-Pelagic	0.28	0.37	0.98	0.91	88
G. Prey	0.18	0.48	1.41	1.07	96
H. Intermediate Predators	0.32	0.47	0.49	0.44	80
I. Large Predators	0.67	0.63	0.68	0.73	74
III. Misc. Catch	1.38	1.11	0.69	0.68	59
IV. Pooled Spp.	0.55	0.71	1.03	0.94	63

Sources : Tables 5.11, 5.14 and Annual Fisheries Statistics, 1975-78
A = Ratio of reported to estimated catch
B = Percentage of estimated catch harvested by FT fleet

comparable in 1975 and 1976, and improved to parity in 1977 and 1978. It is submitted that the relative increase in reported total catch of semi-pelagic taxa was mainly the result of increases in reported catch of semi-pelagic prey, i.e. Kembong. The reported catch of the other semi-pelagic trophic levels did not show any perceptible increase relative to the corresponding estimates calculated in this study. The relative under-estimation of intermediate and large semi-pelagic predators by the Fisheries Division is important because the taxa which make up the trophic levels are, as will be seen later, of increasing economic and biological significance to the FT fleet.

Even though the estimates of total demersal catch by the Fisheries Division and this study are comparable for this four year period, significant differences exist among the estimates for individual demersal trophic levels. The reported catches of Zoobenthic prey (prawns) and Brachyura, which are caught exclusively by trawlers using prawn nets, revealed discrepancies of 26% (in 1975) and 71% (in 1978) when compared with estimates arrived at in this study. The reported catches of the other demersal trophic levels were generally below the estimates of this study. The explanation for these differences probably lie in the failure of the Fisheries Division to stratify the trawl fleet by trawl type, vessel class and net type, and the inadequate sample size of prawn net effort in this study. While it is not possible to say more precisely to what extent each of the above is responsible for the relative under-estimation, the fact of relative under-estimation of the Prawn and Brachyura taxa tends to lend credibility to the suspicion that the estimates of prawn net effort from the trip receipt records may well under-state the prawn net catch.

5.6.5 Estimated FT Fleet Catch

Although the FT fleet represented only 33% of the combined trawler fleet operating in Kedah/Perlis during 1975-1978, it accounted for 63% of the total food fish catch in that period (see Table 5.13, Section B). It accounted for the bulk (88%) of the semi-pelagic taxa, more specifically, 96% of the semi-pelagic prey, and as well, harvested a surprisingly large proportion of demersal intermediate predator which may explain the relatively high fishing mortality on this trophic level.

The catch per taxon of the FT fleet for 1969, and for 1973-1979 as estimated from the cooperative and trip receipt records respectively (in the manner already described) are given in Table 5.14. Total catch of the FT fleet increased steadily from 15215 metric tonnes in 1973 to 26134 metric tonnes in 1979 representing an average annual growth rate of 10%. The number of active FT vessels having grown only at an average of 3% per annum and there being no significant change in nominal effort, the average productivity of the FT fleet in terms of total food fish has increased between 1973-1979.

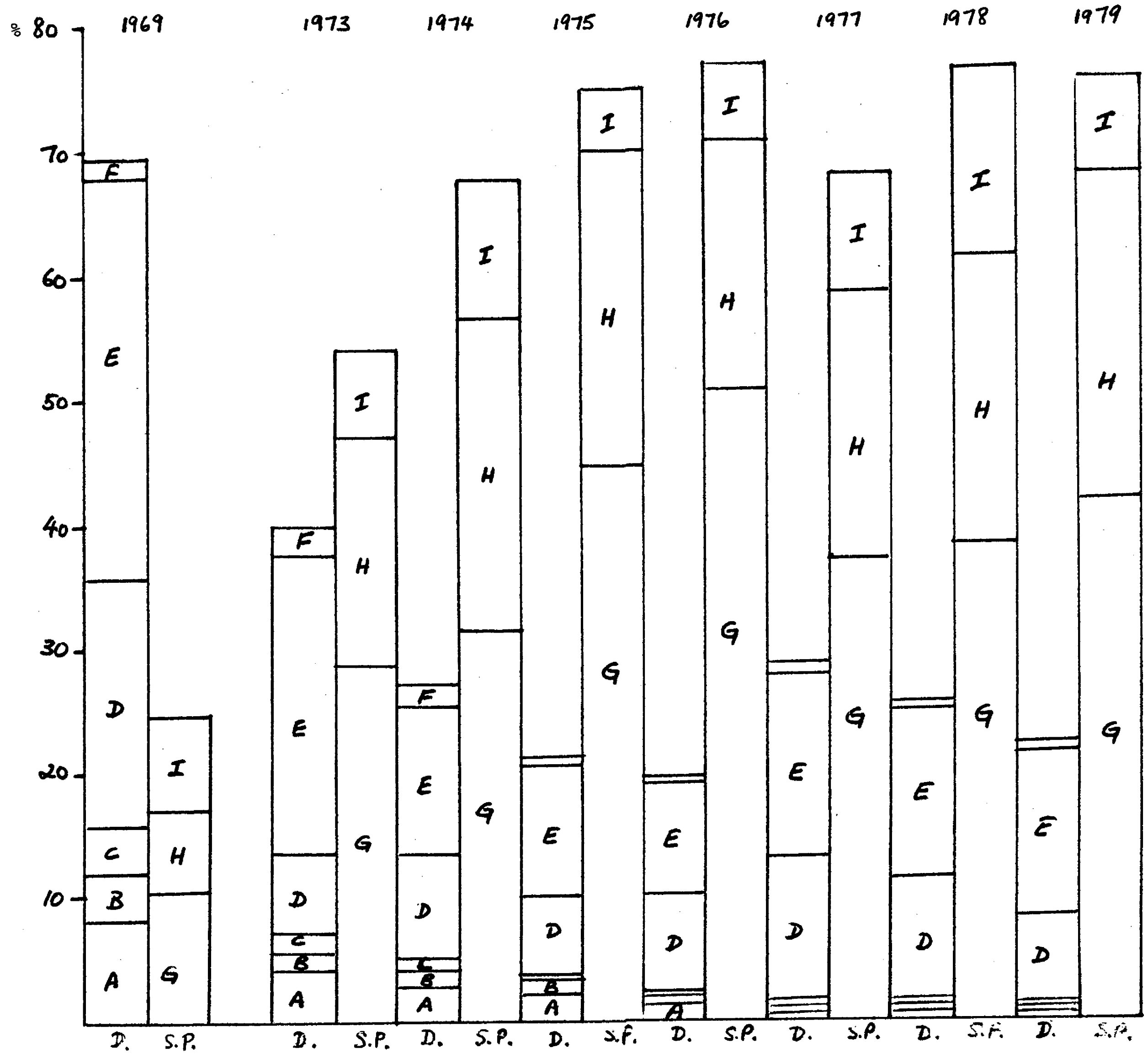
The growth of total catch and average productivity of the FT fleet was mainly achieved by increased concentration on the semi-pelagic taxa through shifts in horse-power class, decreasing use of the prawn net and improved skills of captain and crew. Between 1973 and 1979 the semi-pelagic taxa accounted for the entire growth of fish trawler harvest and its share of total catch rose from 54% in 1973 to 76% in 1979 (see Figure 5.9). The relative shares of the three semi-pelagic trophic levels increased proportionately with the semi-pelagic prey and intermediate predator and represent about 70% of total catch. Kembong, the chief target taxon of the high

TABLE 5.14

ESTIATED FISH TRAWL CATCH BY COMMUNITY, TROPHIC LEVEL AND TAXA FOR 1969 AND 1973-1979 (METRIC TONNES)

		1969	1973	1974	1975	1976	1977	1978	1979
I.)emersal		11763	6078	8209	3818	4128	6155	6006	5845
A.Zoobenthic Prey		1383	654	538	421	303	161	170	165
Prawns	3	1383	654	538	421	303	161	170	165
B.Large Zoobenthic Feeders		1299	186	243	181	111	106	129	139
Rays	17	650	186	243	181	111	106	129	139
C.Brachyura	15	649	269	179	106	60	127	85	86
D.Prey Fishes		3372	960	1611	1127	1668	2476	2303	1820
1 i) Gerridae	6	53	231	529	542	964	1546	921	502
ii) Nemipteridae	7	1112	311	702	443	628	777	1217	1249
2.Flatfishes	11	659	259	184	80	50	111	67	55
3 i) Mullidae	26	1149	84	113	41	11	18	82	8
ii) Leiognathidae	27	399	75	83	21	15	24	16	6
E.Intermediate Predators		5479	3709	2296	1865	1881	3177	3156	3463
1 i) Scianidae	8	2278	1995	538	424	493	1005	1244	1273
ii) Bramidae	19	804	149	180	132	96	202	176	146
iii) Ariidae	22	553	119	173	91	43	98	121	84
iv) Pomadasyidae	24	128	92	148	79	59	84	68	158
v) Lutjanidae	25	89	24	70	96	24	41	56	39
2 Sepioidea	4	655	847	851	600	736	952	652	615
3 a) Sphyraenidae	14	522	346	236	344	319	629	683	900
b) Sharks	21	330	136	197	96	100	146	137	243
c) Drepanidae	29	120	1	3	3	11	20	16	5
F Large Predators		230	300	342	118	105	108	163	172
1 Serranidae	20	71	235	246	94	63	79	125	122
2 Muraenesoadae	23	159	65	96	24	42	29	38	50
II Semi-Pelagic		4170	8234	12903	13471	16108	14800	16757	19813
G Prey		1786	4410	6012	8472	10635	8084	8980	10998
1a) Kembong	1	29	3604	4842	7486	8940	5221	6580	8665
b) Clupeidae	5	1216	399	803	743	1432	1799	1896	1810
2a) Dorosomidae	18	541	403	306	234	248	350	487	493
b) Engraulidae	28	-	4	7	9	15	14	17	30
H Intermediate Predators		1119	2827	4777	4112	4158	4674	5434	6811
1 Loligoidea	2	154	2389	4202	3458	3302	3502	3423	4228
2 Carangidae	10	965	438	575	654	856	1172	2011	2583
I Large Predators		1265	1087	2114	887	1315	2042	2343	2004
1a) Chirocentridae	13	490	430	801	480	759	637	690	598
b) Rachycentridae	30	-	0	3	3	10	9	13	11
2a) Trichiuridae	12	687	502	1042	154	155	1029	1117	972
b) Scomberomoridae	16	88	155	268	250	391	367	523	423
III. Misc. Catch	9	1011	810	1004	678	628	692	581	476
IV Pooled Spp.	31	16944	15215	19116	17967	20939	21647	23344	26134

FIGURE 5.9: TOTAL FISH TRAWL CATCH BY COMMUNITY TYPES AND TROPHIC LEVELS



D : Demersal
S.P. : Semi-Pelagic
A - D: Zoobenthic Prey
B - D: Zoobenthic Feeders
C - D: Brachyura
D - D: Prey Fishes
E - D: Intermediate Pedators
F - D: Large Predators
G - S.P.: Prey
H - S.P.: Intermediate Predators
I - S.P.: Large Predators

opening trawl, alone accounted for more than 33% of total catch in 1979, albeit with fluctuations over the period. The catch of the demersal trophic levels, except for prey fishes and intermediate predator, decreased in relative and absolute terms between 1973 and 1979. The trophic level of the demersal prey fish, although minor relative to the semi-pelagic levels, increased slightly in its share of total catch. The increased catch of prey fish was due entirely to rapid real growth of the two r-strategist taxa, the Nemipteridae and the Gerridae.

A comparison of FT catches in 1969 with 1973-1979 indicates reduced productivity of the demersal stocks, the difference in selectivity between the Thai and high opening trawls, and the relative decline in use of the prawn net. In aggregate terms the fish trawlers were more productive in 1969 with a higher total catch per active trawler than in the later years. This is despite the fact that in 1969 all fish trawlers were Class C and used a prawn net for over 60% of the time. An examination of the average annual revenue per day between 1969 and 1974 in the panggu records does not support the explanation of an 'exceptionally good' year. It seems probable that the demersal taxa, especially the intermediate predators and prey fishes, were more abundant in 1969. Differences in selectivity between the Thai and high opening trawls are clearly demonstrated in the composition of total FT catch in 1969. The relatively small proportion of semi-pelagic taxa harvested in 1969 and, even more, the almost complete absence of Kembong and Loligoidea taxa are outstanding. The relatively high proportion of Prawn, Brachyura and Flatfish taxa in the 1969 catch results from the more extensive use of the prawn net.

5.7 Estimation of Relative Fishing Power

It was seen in Chapter 4 that the usual method for estimating the fishing effort of a heterogeneous fleet is to adjust the nominal fishing effort of its vessel-gear types by their respective relative fishing power. To estimate the relative fishing power, two basic approaches have been used. One is to conduct controlled comparative fishing experiments and the other is to compare the performance of a fleet with catch and effort statistics. In this case, as experimental information was not available the CPUE estimates derived from the trip receipt records have been used to estimate the relative fishing power of each vessel-gear type.

Gulland (1956) discussed a method that employs analysis of variance to adjust the relative fishing power of different vessels. Robsons (1966) improved it by applying a maximum likelihood technique. Berube and Abramson (1972) subsequently wrote a computer program called FPOW based on the procedure suggested by Robsons which has become the standard package for derivation of relative fishing power in most rigorous studies of complex fisheries [Low, 1974; Hongskul,1975].

The basic model of FPOW is the familiar multiplicative catch equation:

$$C_{ij} = q_i f_{ij} \cdot \bar{X}_j \cdot e_{ij} \qquad 5.1$$

where :

ij = the ith vessel-gear type in the j time period,

C = catch,

and, q = catchability coefficient,

f = fishing effort,

$\bar{X}$ = mean population biomass,

and, e = log normal random variable.

Dividing equation 5.1 by f_{ij} and taking the natural logarithms of both sides :

$$Y_{ij} = a_i + B_j + E_{ij} \qquad 5.2$$

where :

$Y_{ij} = \ln(C_{ij} / f_{ij})$

$a_i = \ln q_i$

$B_j = \ln \bar{X}_j$

and, $E_{ij} = \ln e_{ij}$

Equation 5.2 is in the form of a linear two-factor analysis of variance model. However, the design matrix is singular and the parameters cannot be estimated. If the model is re-parametrised by standardising the original parameters, then

$$Y_{ij} = u + a_i' + B_j' + E_{ij} \qquad 5.3$$

where :

$$u = a_j + B_j$$

$$a_i' = a_i - a_j$$

$$B_j' = B_j - B_s$$

and s designates the vessel-gear type and time period selected to be standard.

The model is full rank and the parameters can be estimated by solving the usual normal equations. The parameters, however, provide biased estimates of relative fishing power, P_i, and relative population density, D_j, because they are calculated in logarithms. FPOW applies an approximate correction of this bias based on Laurent (1963), where:

$$P_i = \exp\,(a_i')\ [1 - 0.5\ \mathrm{Var.}(a_i')]$$

$$D_j = \exp\,(B_j')\ [1 - 0.5\ \mathrm{Var.}(B_j')]\ .$$

Using annual CPUE derived from available trip receipt records, the relative fishing power of all vessel-gear types covered was estimated with the FPOW program. Class D fish trawlers using high opening nets, vessel-gear type 342, was used as the standard for all taxa except Prawns, Flatfish and Brachyura. In these excepted taxa, Class D fish trawlers using prawn nets vessel-gear type 343, was the standard. These vessel-gear types were chosen because they were the only vessel-gear types for which CPUE were available for the entire

1973-1979 period. It was assumed that the fishing power of all vessel-gear types was constant throughout 1973 to 1979 since the input vector of Classes C and D fish trawlers, and Class A SPT vessels remained rather constant in that period. The majority of secondary innovations, such as larger gear boxes and larger nets, having affected primarily Class E vessels, the fishing power of this vessel-gear type was assumed to change annually.

The relative fishing power of all FT vessel-gear types except those using a Thai trawl and Class A SPT vessels are given in Table 5.15. As expected these estimates of relative fishing power generally increased with vessel class; the relative fishing power for pooled taxa increasing by about 17% with each vessel class. The relative fishing power of 10 of the major taxa increased directly with vessel class. The exceptions were Prawns, Sepioidea and Flatfishes the relative fishing powers of which appear to be unrelated to vessel class. The relative fishing powers of vessel-gear type 352 exhibited considerable instability over the years especially in the case of pooled taxa. The only discernible trend is a steady increase in the relative fishing power of Carangidae, Gerridae and Sphyraenidae taxa. Although the relative fishing power for pooled taxa increased directly with vessel class for prawn trawlers, the estimates for individual demersal taxa showed a very mixed pattern. An interesting observation is that inspite of the relatively small size and fishing power of pooled taxa, the vessel-gear class 113 was quite efficient in harvesting its target taxa, Prawns, Sepioidea, Flatfish and Brachyura.

TABLE 5.15: RELATIVE FISHING POWER OF THE VESSEL-GEAR TYPES FOR WHICH TRIP RECEIPT RECORDS WERE COLLECTED

Year(s) :		All	All	1975	1976	1977	1978	1979	All	All	All	All
Vessel-gear code :		342	332	352	352	352	352	352	343	113	333	353
I. Demersal												
A. Zoobenthic Prey												
Prawns	3	0.004	0.005	0.000	0.002	0.005	0.002	0.000	1.000	0.799	0.998	0.606
B. Large Zoobenthic Feeders												
Rays	17	1.000	1.470	0.929	1.066	0.588	0.856	1.041	2.369	0.997	3.074	1.748
C. Brachyura	15	0.260	0.179	0.249	0.246	0.359	0.163	0.278	1.000	0.607	0.580	1.334
D. Prey Fishes												
1(a) Gerridae	6	1.000	1.178	1.557	1.147	1.149	1.252	1.923	0.612	0.386	0.440	1.062
(b) Nemipteridae	7	1.000	0.913	0.886	1.120	0.714	0.790	1.331	0.643	0.485	0.356	0.543
2. Flatfishes	11	0.032	0.022	0.007	0.006	0.013	0.030	0.000	1.000	0.660	0.740	1.164
3(a) Mullidae	26	1.000	0.227	0.118	0.078	0.263	2.554	0.119	0.218	0.079	0.313	0.494
(b) Leiognathidae	27	1.000	1.345	0.000	0.108	0.107	0.140	0.100	1.023	0.000	2.409	0.000
E. Intermediate Predators												
1(a) Scianidae	8	1.000	0.687	0.368	1.374	0.962	1.136	4.040	1.445	0.361	0.546	2.087
(b) Bramidae	19	1.000	0.950	2.794	1.354	1.667	0.935	1.386	1.234	0.191	0.927	2.644
(c) Ariidae	22	1.000	0.266	0.790	1.963	0.355	0.244	1.121	0.245	0.049	0.121	0.147
(d) Pomadasyidae	24	1.000	1.121	1.089	1.850	2.137	1.867	3.524	0.856	0.027	0.636	0.857
(e) Lutjanidae	25	1.000	1.280	0.177	0.830	2.442	0.881	2.361	0.610	0.285	0.985	1.782
2. Sepioidea	4	1.000	0.635	0.656	0.980	0.704	0.810	0.798	1.522	0.854	0.721	0.975
3(a) Sphyraenidae	14	1.000	1.042	0.408	1.181	0.738	1.825	4.306	0.302	0.038	0.750	0.602
(b) Sharks	21	1.000	1.329	2.652	1.419	1.264	1.069	1.832	0.921	0.227	0.271	1.401
(c) Drepanidae	29	1.000	1.292	0.000	0.157	0.000	0.287	1.635	0.240	0.049	0.220	0.033
F. Large Predators												
1. Serranidae	20	1.000	0.648	1.567	1.286	0.726	0.739	1.188	0.803	0.835	1.036	2.379
2. Muraenesoadae	23	1.000	0.478	0.040	0.741	0.218	0.414	0.811	2.152	0.625	0.509	0.837
II. Semi-Pelagic												
G. Prey												
1(a) Kembong	1	1.000	0.822	0.979	1.268	1.048	1.276	1.209	0.002	0.007	0.006	0.002
(b) Clupeidae	5	1.000	0.881	0.734	1.311	1.310	1.225	1.134	0.038	0.020	0.042	0.056
2(a) Dorosomidae	18	1.000	0.714	0.895	1.153	0.647	0.801	1.142	0.340	0.059	0.120	0.589
(b) Engraulidae	28	1.000	0.806	1.103	0.553	0.100	0.244	1.244	0.658	0.009	0.185	0.199
H. Intermediate Predators												
1. Loligoidea	2	1.000	0.989	2.406	1.102	1.251	1.194	1.090	0.549	0.103	0.350	0.527
2. Carangidae	10	1.000	1.147	1.487	1.242	1.333	1.402	2.353	0.059	0.060	0.061	0.028
I. Large Predators												
1(a) Chirocentridae	13	1.000	0.723	2.058	0.976	1.101	1.037	1.307	0.326	0.085	0.344	0.495
(b) Rachycentridae	30	1.000	0.434	1.492	1.632	0.401	0.526	0.516	0.958	0.011	0.000	0.188
2(a) Trichiuridae	12	1.000	0.800	0.489	0.349	1.047	1.053	0.825	0.226	0.054	0.099	0.048
(b) Scomberomoridae	16	1.000	1.325	1.855	0.897	1.299	1.448	1.324	0.402	0.050	0.147	0.049
III. Misc. Catch	9	1.000	0.686	1.484	1.181	0.721	0.541	0.554	1.303	0.317	0.842	2.650
IV. Pooled Spp.	31	1.000	0.845	1.234	1.174	1.041	1.132	1.348	0.609	0.286	0.475	0.657

5.7.1 Relative Fishing Power of Thai Trawl Vessels

It was not possible to estimate the relative fishing power of vessel-gear type 331 conjointly with the other vessel-gear types because the only data available on these vessels, which used the Thai trawl, were from the 1969 cooperative records. It was therefore necessary to employ a more indirect and less exact procedure which used the trawl vessel survey.

The 1970, 1971 and 1974 trawl surveys were carried out using two identical vessels, Penyelidek I and Penyelidek II. Both vessels had the following characteristics which were retained throughout the 1970-1974 period:

1. Total length...............23 meters (75.5 feet)
2. Gross tonnage..............85 tonnes
3. Main engine................Caterpillar, D-343
4. Main engine, h.p...........365 @ 1800 r.p.m.
5. Gear box reduction ratio...1:4

A Thai trawl with a 40 mm. mesh in the cod end was used in each survey. All hauls except those aborted because of gear damage were limited to 60 minutes at a speed of 2.8 knots.

The trawl survey results are reported in kilograms per taxon per hour, which enabled them to be converted to a form comparable to the estimates of CPUE from trip receipt records. In 1974 the average trawler planned to make three three-hour hauls per day (see Table 5.7). However, they were at times prevented from fishing the full 9 hours by net and engine break-downs, storms and exceedingly large catches. The general agreement of market agents interviewed was that fish trawlers actually fished for 8.1 hours per day or 90% of the planned period. The CPUE of the survey vessel was then estimated by multiplying the reported catch by 8.1, the average hours fished per day by vessel-gear type 343, and by 1.658, a constant used to convert kilograms into katis. The fishing power of the survey vessel relative to the standard vessel-gear types was estimated by the ratio of the CPUE for the survey vessel during the 1974 survey to the CPUE of the standard vessels during November and December 1974, which were the months during which the trawl survey was conducted. The relative fishing powers of the survey vessels is given in Table 4, Appendix C.

The fishing power of the Thai trawl vessels relative to the standard vessel-gear types was established by first estimating the fishing power of Thai trawl vessels in 1969 relative to the survey vessel via ratio of means estimator and then multiplying this ratio by the relative fishing power of the survey vessel. The CPUE of the survey vessel used in the ratio estimator were obtained by multiplying the results of the 1970 trawl survey by 5.4, the average hours fished per day by vessels using the Thai trawl in 1969 and by 1.658, the kilogram to kati conversion factor. The CPUE of Thai trawl vessels was then calculated using cooperative records from November and December 1969. The relative fishing power of Thai trawl vessels are given in Table 4, Appendix C.

On the assumption of uniform fishing power, the trawl survey results provided a measure through which the two temporally discreet sets of catch data can be compared. However, the small number of hauls (from 40-60 per survey), and the short time period, heightened by the large random inter-haul variation in catch rate, augment potential sampling error. Moreover if abundance or availability of taxa population changed between 1969 and 1970, the use of 1970 trawl results to establish the relative fishing power of Thai trawl vessels in 1969, would introduce bias. In the absence of a superior alternative means of comparing records of the cooperatives and trip receipt records, this method had to suffice. It ought to be noted that notwithstanding its lack of sophistication, the resultant estimates appear to be consistent with the earlier analysis of total FT catch.

5.8 Standardised Fishing Effort

The standardised fishing effort of the combined trawl fleet by taxa and year was derived by adding the nominal effort of all trawl vessel-gear types adjusted by their respective relative fishing powers. The annual nominal fishing effort of all vessel-gear types active from 1973 to 1979 were estimated as described in section 5.4. The annual nominal fishing effort of SPT and PKT vessel-gear types for 1969-1974 were assumed, for lack of more accurate information, to have been equal to their respective average annual nominal fishing effort over the 1975-1979 period. The annual nominal effort of the FT fleet for 1969-1979 is given in Table 5.7. However, these estimates were adjusted for changes in hours fished per day by applying the correction factors in Table 5.8.

The relative fishing powers of all vessel-gear types were assumed to have remained constant throughout 1969-1979. The only exception being vessel-gear type 352, the relative fishing power of which was assumed to have remained constant from 1971 to 1975. The vessel-gear types employed as proxies for the Pulau Ketam trawlers and Classes B and C small prawn trawlers to estimate total catch (section 5.6) were again used to represent the relative fishing power of the vessel-gear types as adjusted wherever possible for differences in relative performance. Total annual standardised effort per taxon for the 1969-1979 period is given in Table 5, Appendix C.

5.9 Catch Per Unit of Standardised Effort (CPUSE)

The range of CPUE estimated in this study is insufficiently adequate to provide estimates of catch per taxon from the combined trawl fleet for more than four years. Thus the CPUSE had to be estimated from vessel-gear types for which records were available. Furthermore some taxa are harvested by prawn or high opening trawls only incidentally. The CPUE of incidental taxa is unstable and is likely to be determined more by fluctuations in relative availability than taxa abundance.

The CPUSE for each taxon was thus calculated as follows

$$CPUSE^{i}_{j} = \frac{\sum_{k=1}^{a}\left(NE^{i}_{jk} \times \frac{(CPUE^{i}_{jk})}{(e^{i}_{jk})}\right)}{\sum_{k=1}^{a}\left(NE^{i}_{jk}\right)}$$

where :

i = ith year,

jk = jth taxa and kth vessel-gear type,

CPUSE = catch per unit standard effort,

NE = total nominal effort,

CPUE = catch per unit effort,

e = relative fishing power,

and, a = number of appropriate vessel-gear type for which catch records were available.

The number of vessel-gear types used to calculate CPUSE for each taxon was determined by the size of the relative fishing power. Where the relative fishing power was below 0.25, the vessel-gear class was defined as inappropriate in the sense that the taxon was only harvested incidentally and was excluded in the calculation of the CPUSE. On this decision criterion, the CPUSE of 1. Prawns, Flatfishes and Brachyura were estimated using only prawn trawl vessel-gear types, 2. all semi-pelagic taxa as well as Gerridae, Ariidae and Drepanidae were estimated with the use of only fish trawl vessel-gear types, and 3. all other taxa were estimated with the use of all vessel-gear types.

As trip receipt and cooperative records were only available for 1969 and the 1973-1979 period, the CPUE of the survey vessel divided by its relative fishing power had to be used to estimate CPUSE for 1970 and 1971. Further, in order to obtain a continuous time series, the CPUSE per taxon in 1972 was estimated by means of CPUSE in 1971 and 1973 weighted by their respective total standard effort. The CPUSE per taxon from 1969 to 1979 is given in Table 6, Appendix C.

5.10 Purse Seine Fleet

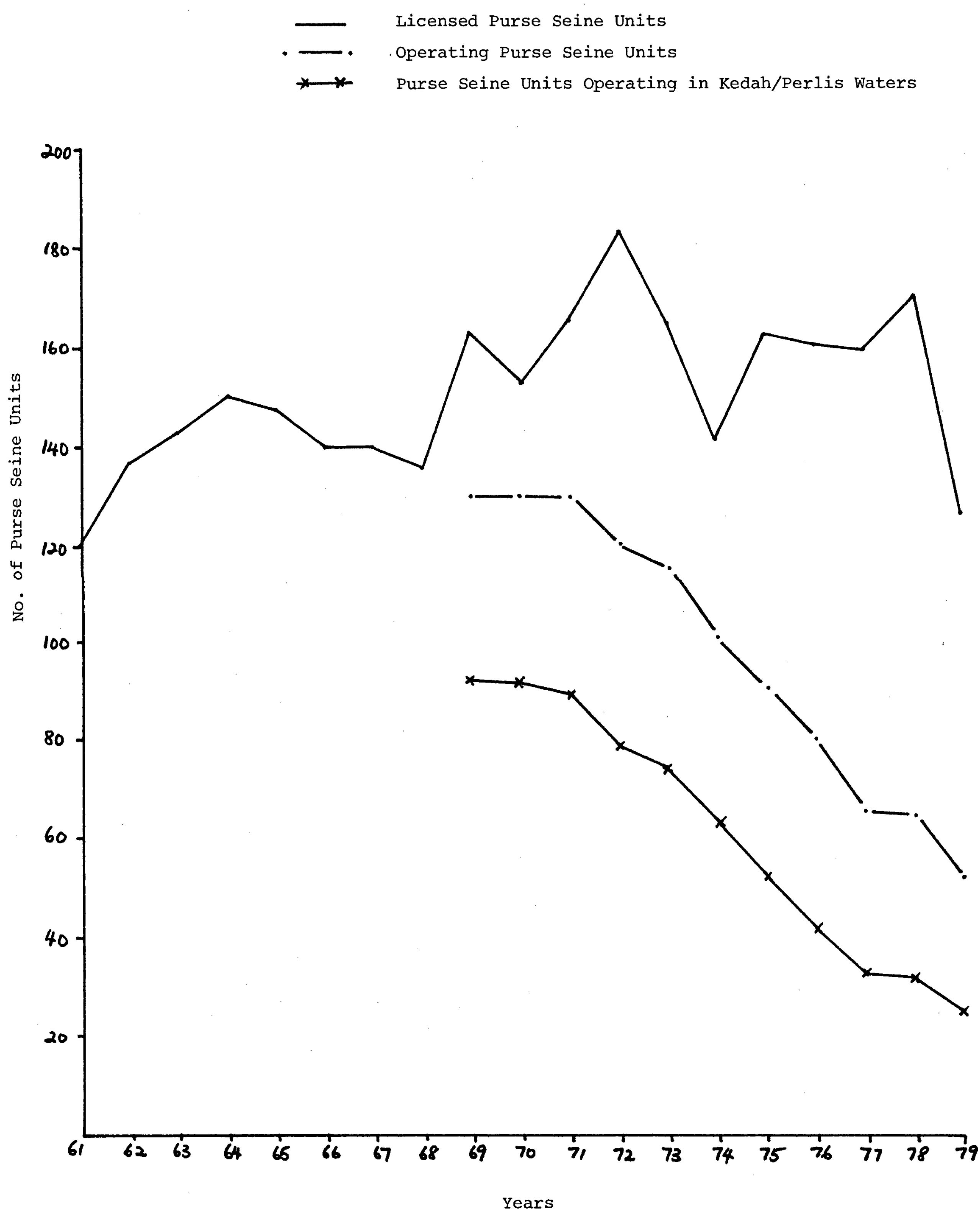
As was explained at the outset, the rather involved considerations, estimates and calculations in this chapter are primarily a prelude to the surplus production functions estimated in Chapter 6. Attention has of course been focused on the trawl fleet. Some additional discussion of the Purse Seine fleet should, however, be made before we prodeed to Chapter 6.

5.10.1 Purse Seine Numbers

With the introduction of the trawler, the Kedah/Perlis purse seine fleet declined notably in active units and in purse seine types. The extent of this decline is illustrated by the sharp, continuous decrease in total operating units since 1971 (Figure 5.10). No quantitative or monetary limitations have ever been imposed on purse seine licences by the Fisheries Division. In fact, in recent years it has, at least in principle, encouraged the adoption of the purse seine as a substitute for trawlers. Although a number of purse seine net owners have renewed their licences in the hope of a successful season, they have increasingly decided against their use, thus suggesting diminished profitability. In 1969, 130 active purse seine units operated in the Kedah/Perlis waters; by 1971 only 52 did. Admittedly the majority of the purse seine units are only based in Kedah/Perlis, to take advantage of the high fish and low diesel prices, and operate in Thai waters with Thai crews. Nonetheless the estimated number of purse seine units actively fishing in Kedah/Perlis waters is also on the decline. In 1971 there were 89 active units but by 1979 only 25 remained. The lure, which was used quite widely by purse seines, exclusively or during periods of low Kembong catch, also disappeared. By early 1973 all purse seine units actively fishing in Kedah/Perlis were night purse seines (or pukat jerut malam). The trawlers had through gear interference destroyed the lures and reduced the profitability of purse seines by reducing jointly exploited fish stocks.

The decline of the purse seine fleet after 1971 seems to indicate heightened biological and economic competition from the FT fleet. The FT fleet, as will be discussed later, shifted to the use of a different net which increased their access to many of the same semi-pelagic species exploited by the purse seine. Indeed the possible direct biological competition between the fish trawl and

FIGURE 5.10: LICENSED AND OPERATING PURSE SEINE UNITS IN KEDAH/PERLIS
1961 - 1979



the purse seine fleets is the primary reason for the inclusion of the purse seine in this study.

5.10.2 Purse Seine Nominal Fishing Effort

The purse seine owners kept trip receipt and panggu records for successful days fishing. The problem is that only a portion of the actual day trips were successful. However, even on the unsuccessful trips purse seine vessels do sample the fish populations via searching. The best available measure of nominal fishing effort as in the case of the trawl fishery is thus the number of days at sea. The only information that could be obtained on days fishing for purse seines is from the ice receipts of a particularly helpful market agent who owned six purse seine vessels. From these records it was estimated that on the average these vessels went to sea for about 17 days per month. Assuming that the maximum number of days fishing per month as determined by the cycle of the moon is 22, this estimate represents a 77% use rate of available time as compared to the 67% use rate by the trawl fleet. The eight days off per month allow the purse seine units time for necessary rest, repair and maintenance, and replenishment of supplies, thus contributing to the more efficient use of available time. The estimated 23% of available time lost, because of weather conditions, engine breakdowns, absenteeism of crew, damage to nets and other unforeseeable events appears reasonable when it is compared with the estimated actual number of days fished per month by a sample of 24 purse seine units in Kuala Kedah in November and December 1951 [Heong, 1951, p.40]. The purse seine vessels in that study averaged 13.2 days fishing per month but their use of non-synthetic nets and less reliable engines could explain the extra four lost fishing days. In the absence of better information, it will be assumed that the active purse seine fleet in Kedah/Perlis averaged 17 days fishing per month.

Information on time spent at sea by the purse seine fleet is also limited. The total time spent searching is difficult to predict depending on such variables as the cycle of the moon, choice of fishing grounds, winds [winds over force 4 obstruct the location of fish schools by decreasing the visibility of their wakes] and whims of the captain. The purse seine owners thus found it difficult to give estimates of the average number of hours at sea per day. The vessel owners who had provided the ice records from which the average number of days fishing per month were calculated had for some undisclosed reason kept log books for two of his purse seine vessels in January 1978. A summary of the log books is given in Tables 1a and 1b, Appendix C. For the month sampled, these two vessels averaged 10.8 hours per day at sea. But according to the 1951 purse seine study, the sampled vessels averaged 16.8 hours per day at sea [Heong, 1951, pp.50-58]. The discrepancy between the two estimates may be the result of numerous factors, not the least of which is sampling error. What does emerge from the only recent information on time at sea, that is the logs, is that there has not been any trend towards increasing actual fishing time. Finally, the estimate of 10.8 hours per day at sea in the case of the two purse seine vessels represents 30% less hours per day than that for fish and PKT trawlers, and 10% less than the corresponding figure for the SPT fleet.

Available data on successful days fishing per month, number of panggu per year and months fishing per year, all confirm the rapid decline of the average purse seine unit as a viable economic entity

(Table 5.16). The number of successful days fishing per month fell from 15.6 in 1969 to a low of 4.9 in 1977 followed by a faint recovery in 1978 and 1979 on the assumption of 17 days fishing per month throughout the 1969-1979 period. Put differently, the purse seine fleet was on the average successful for 93% of the time in 1969 but only for 29% of the time in 1977. The frail success of the purse seine fleet suggests a decline in mortality inflicted on exploited fish populations by purse seine fishing, and the deteriorating viability of the fishing unit type. The estimated number of months fishing per year gives an indication of the extent to which the owners decide to tie up their vessels during slack periods. As shown in Table 5.16, the owners sampled operated a full 12 months each year inspite of the declining success. The only exceptions were the two worst years of 1976 and 1977. The number of panggu per year which is an indirect measure of the financial success of a unit displays the same pattern as revealed by the number of successful fishing days.

5.10.3 Purse Seine CPUE

Annual estimates of purse seine CPUE were derived in the same manner as the CPUE of the trawler vessel-gear types except that the number of days fishing per month was assumed to be 16.8 throughout 1969-1979. The annual CPUE derived from the trip receipt records for 1974-1979 are given in Table 5.17.

Table 5.17 shows that the purse seine and trawler jointly harvest and compete for 13 taxa. But only three of these taxa were harvested, other than incidentally, by the purse seine fleet from 1974-1979. They were the Kembong, Clupeidae and Carangidae. The purse seine fleet harvests three other food fish taxa not exploited by the

TABLE 5.16

AVERAGE SUCCESSFUL DAYS FISHING PER MONTH,
PANGGU PER YEAR AND MONTHS FISHING PER YEAR FOR THE PURSE SEINE FLEET

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Av.
1. Successful fishing days	15.6	13	11.5	9.1	10.2	8.2	7.5	5.2	4.9	7.3	7.4	7.9
2. No. of Panggu	10.3	10.4	8.2	8	8.7	8.9	4.8	6	7.4	8.8	8.8	8.1
3. Months fishing	11.9	11.8	12	11.7	11	11.2	11.7	9.2	9.3	11.9	11.9	11.1
No. of observations	4	5	6	6	8	8	6	5	8	5	4	65

Source: Panggu Records

TABLE 5.17: CPUE PER TAXON OF PURSE SEINE FLEET FROM 1974-1979

	Taxa No.	1974	1975	1976	1977	1978	1979
Jointly Exploited Taxa[1]							
Kembong	1	511.61	445.17	243.59	169.46	156.32	165.28
Clupeidae	5	122.63	37.04	11.25	2.89	56.24	2.91
Carangidae	6	134.65	153.33	151.51	377.13	574.38	527.42
Scianidae	8	0	0.22	0	0	3.72	0
Miscellaneous catch	9	3.43	6.36	0.06	37.49	7.19	0
Chirocentridae	13	0	0	0	0	1.64	0
Sphyraenidae	14	33.00	111.91	0	0	3.07	0
Scomberomoridae	16	1.73	2.67	1.09	14.39	19.16	0
Rays	17	0	0.38	0	0	0	0
Dorosomidae	18	0.39	3.83	0	0	4.46	0.09
Bramidae	19	0	0.03	10.12	0	2.64	2.71
Sharks	21	0.52	0.34	0.95	3.18	17.95	0
Ariidae	22	8.88	58.63	0	0	0.36	14.07
Subtotal	31	784.16	819.91	418.56	601.85	847.14	712.58
Non-Jointly Exploited Taxa [2]							
Tuna [3]	-	78.78	209.25	216.55	359.12	230.16	354.40
Other Carangidae [4]	-	38.11	2.59	2.64	0.79	0.11	0
Dussumieridae	-	0	3.09	0	2.37	6.40	0
Trash fish	-	14.12	7.53	7.69	33.04	3.79	1.49
Pooled spp.	-	915.17	1042.37	645.58	997.17	1087.50	1068.47

Source: Trip Receipt Records

[1] These include those taxa exploited jointly by trawlers and purse seine vessels.

[2] These are taxa harvested by purse seine vessels but not by the trawlers.

[3] The Tuna taxa includes two species, Bonito (<u>Euthynnus alleteratus</u>) and Albacore (<u>Germo siblo</u>) which are scombrids. Since Kembong is of the same family, neither catch category was labelled as representative of Scombridae.

[4] The other Carangidae taxa includes 3 Carangid species not harvested by trawlers. These are <u>Decapterus russeli</u>, <u>Selar Crumenophthalmus</u> and <u>Elagatis Bipinnulatis</u>. Their respective Malay names are <u>Selayang</u>, <u>Pelata Bulat</u> and <u>Pisang-Pisang</u>.

trawler fleets: the Tuna, Dussumuridae and other Carangidae (which is composed of carangids not exploited by the trawl fleets). Here again only Tuna were consistently caught in significant quantities.

It has already been established that the purse seine fleet was in a state of rapid decline with the number of active vessels and the nominal effort falling simultaneously. The hypothesis advanced to explain this decline was that the purse seine fleet was suffering from falling revenue and therefore from falling CPUE. But the CPUE presented in Table 5.17 do not support it. The purse seine CPUE for total jointly and non-jointly exploited taxa did not indicate a trend, negative or positive, over the 1974-1979 period.

A closer examination of the relative share of total purse seine catch by major taxa in Table 5.18, shows that despite the absolute and relative decline of Kembong and Clupeidae, the other two major taxa, Carangidae and Tuna increased in a compensating manner leaving the four major taxa's share of total catch unchanged at about 90%. Kembong, which has been the target taxon of the purse seine fleet ever since its introduction, is particularly the target taxon of the night purse seines, the only type of purse seine unit presently operated. Since 1974 its share of total catch has fallen from 56% to 15% in 1979. This was accompanied by a fall, albeit at a slower rate, in its percentage of total successful trips: from 95% in 1974 to 56% in 1979. Clupeidae followed the same pattern as Kembong but at a faster rate of decline. The compensating growth of Carangidae and Tuna catches, which increased from 15% and 9% respectively in 1974 to 49% and 33% of total catch in 1979, was to a large extent the result of targeting. The percentage of the successful trips in which Carangidae and Tuna were caught increased from 57% and 50% respectively in 1974

TABLE 5.18: SHARE OF ANNUAL PURSE SEINE TOTAL CATCH AND PERCENTAGE OF NUMBER OF SUCCESSFUL TRIPS DURING WHICH MAJOR TAXA WERE CAUGHT

	1974	1975	1976	1977	1978	1979
Kembong						
% of total CPUE	56	43	38	17	14	15
% of successful trips	95	98	63	83	96	56
Clupeidae						
% of total CPUE	13	4	2	0.3	5	0.3
% of successful trips	40	50	31	17	42	11
Carangidae						
% of total CPUE	15	15	23	38	53	49
% of successful trips	57	38	38	92	92	78
Tuna						
% of total CPUE	9	20	34	36	21	33
% of successful trips	50	65	81	83	92	100
Total %	93	82	97	91.3	93	97.3

to 78% and 100% in 1979. The growth rates in relative frequency of Carangidae and Tuna catches were too high to have been derived predominantly from enhanced abundance. The probable explanation is a shift by purse seine captains from Kembong grounds in an attempt to offset the drop in Kembong catch.

5.10.4 Exclusion of Purse Seine Effort and CPUE

The CPUE and effort of the purse seine fleet were not included in the estimation of either CPUSE or total standardised effort because the trends in CPUE and effort are probably, as is the case in many other purse seine fisheries, more a result of declining availability (particularly in the cases of Kembong and Clupeidae) than of stock abundance. The availability of a given taxon to the purse seine fleet, as has been noted, is governed by the number, size, density, and spatial distribution of the fish schools it pursues. Changes in these school characteristics and therefore availability need not be reflected in abundance (see FAO, 1976, p.7).

According to trawler captains, (many of whom had worked on purse seine vessels) and purse seine captains, the decline in purse seine CPUE and effort has resulted more from a decline in the availability rather than the abundance of exploited taxa. These men maintained that the introduction of the trawl not only eliminated the use of the lure and decreased the abundance of most taxa, but, more importantly, led to the fragmentation of the fish schools and/or a reduction in schooling behaviour (particularly for the Kembong and Clupeidae) without there being any spatial concentration of the taxon. The result of this process is an equivalent number of smaller, less dense schools distributed over the original area. Since a fish school must be of a minimum density and size to throw up a wake large enough to be spotted by the purse seine crews, the decline in school size resulted in the decline in the proportion of the taxon populations visible, hence available.

A comparison of purse seine CPUE and trawler CPUE substantiates the conclusion that the former is a relatively inaccurate index of taxa abundance. It also illustrates the difficulty of combining catch and effort data for these two fishing unit types with radically different catchability coefficients. The annual relative fishing power of the purse seine fleet for Kembong and Clupeidae as shown in Table 5.19 which was estimated by dividing the annual purse seine CPUE by the annual CPUE of vessel-gear type 342, displays a steady decline over the 1974-1979 period. In contrast, the population density estimated by the FPOW program using all annual trawler CPUE, increased for Kembong from 1974 to 1976, and for Clupeidae from 1974 to 1979. Even Carangidae which replaced Kembong as the primary target taxon exhibited a small decline in relative fishing effort between 1975 and 1978.

TABLE 5.19: COMPARISON OF TRENDS IN STOCK DENSITY [1] AND RELATIVE FISHING POWER [2] OF PURSE SEINE VESSELS

	1974	1975	1976	1977	1978	1979
1. Kembong						
a. Rel. fishing power	5.112	3.483	2.314	1.743	1.564	1.947
b. Density	0.896	1.384	1.526	0.929	0.831	1.209
2. Clupeidae						
a. Rel. fishing power	13.49	3.272	1.274	0.117	2.104	0.159
b. Density	1.359	1.329	2.409	2.57	2.515	2.082

[1] Density calculated by FPOW program.
[2] Relative fishing power was estimated by dividing the annual Purse Seine CPUE by CPUE of vessel-gear type 342.

CHAPTER 6

SURPLUS PRODUCTION

6.1 Introduction

This chapter presents the results of the surplus production models estimated for the component taxa exploited by the Kedah/Perlis trawl fleet and discusses the results for the fishery as a whole with special attention to the results of the 12 major taxa. It is proposed to preface the presentation with a brief description of the basic assumptions of the surplus production model, a consideration of their general applicability to the fish stock under study, and a discussion of the choice of such models.

6.2 Assumptions of Model

The conditions necessary for the simple surplus production model to validly represent the dynamics of population growth [Pella and Tomlinson,1969; Schnute,1977] are:

1. the population and its age distribution must be measured under equilibrium conditions,
2. the variability in population growth from natural activity should be negligible,
3. each taxon must represent a closed and single unit population,
4. the range of age groups exploited by the trawl fleet has remained constant, and,
5. the taxon represents independent population, that is, inter-specific competition and/or predation is negligible.

6.2.1 Equilibrium Conditions

It was seen in Chapter 5, that the fishing intensity exerted by the Kedah/Perlis trawl fleet grew at a rapid rate over the 1969 -1979 period with an average annual growth rate of 32%. The growth rate of fishing effort on semi-pelagic species was particularly high primarily as a result of a low initial level of exploitation. In view of such rapid growth rate in fishing effort, it is unlikely that many taxa have been able to reach an equilibrium in age distribution or in population size. If so, the estimates of CPUSE measure transitional and not steady state conditions.

The relationship between transitional and steady state conditions will naturally depend upon the time lag in the population's response to fishing mortality. For short-lived fishes, such as semi-pelagic prey and prawns, the adjustments in natural mortality, growth rate and recruitment will take place very quickly such that the transitional would closely approximate equilibrium conditions. In the case of the longer living fishes, such as demersal predators and zoobenthic feeders, the time required to fully adjust the population parameters to changes in fishing mortality can be expected to take a number of years.

Gulland (1964) recommended using a moving average of effort as a means of incorporating the time lag inherent in the adjustment process. Schnute (1977) presented a model based on the logistic curve wherein changes in CPUSE are not only a function of present and past effort, but are also a moving average of CPUSE. This model is intrinsically more plausible given the obvious direct causal relationship between the levels of past and present abundance to changes thereof.

The moving average of fishing effort was employed in the surplus production models used to estimate the equilibrium yield function of the 31 taxa. However, only a one year moving average could be used because of the limited period for which effort data were available. It is therefore possible that the moving average may still represent transitional conditions for some taxa.

The rapid increase in fishing intensity in the trawl fleet may also have resulted in a continuous decline in the price of the catch through growth over-fishing. This would have occured if the average size or grade of fish decreased and/or if the portion of the catch assigned to trash increased.

The extent, if at all, to which the fish populations have actually been over-fished, in terms of exploiting immature or unrecruited fishes, cannot be determined without adequate weight/length data on the catch including trash fish. In any event, checking over-fishing by controlling the size of individual fishes at first capture (and thereby alledgedly maximising yield), known as eumetric fishing, is not feasible in a complex fishery such as the one in question. The range of minimum eumetric sizes of the exploited taxa is so large that it is a formidable task to set the 'optimum' mesh size even if accurate life history data is available. Besides, mesh regulations in the past have proven unenforceable. However, the extent to which the average price of individual taxon has dropped due to, at least in part, non-eumetric fishing may be checked by examining the trend in the grade composition of the recorded catch.

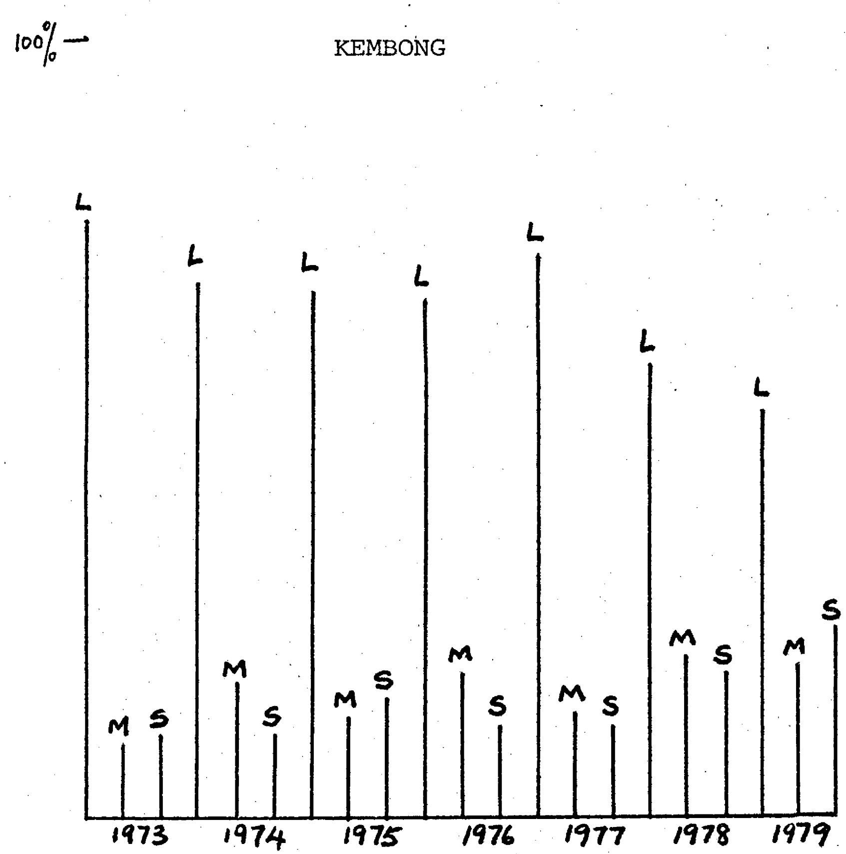
In the trip receipt records, 16 fish categories are described as 'large', 'medium', and 'small', and 11 others as 'large' and 'small'. These categories represent 12 and 8 taxa, respectively, which are graded on the basis of economic value and not size. Thus the size range of each grade may vary annually and even seasonally. The catch composition by grade of the 8 graded (out of 12) major taxa is given in Figures 6.1a - h while Figures 1a - 1 in Appendix D give that of the remaining graded minor taxa. From Figure 6.1, it is clear that there is no general trend towards an increasing share of small fishes in the trawl catch or the associated decrease in average price of edible catch. Only two major taxa, Kembong and Flatfishes (Figures 6.1a and 6.1h respectively), and two minor taxa, Rays and Ariidae (Appendix D), display a discernible pattern of a progressively larger portion of smaller individuals. The catch of a number of major taxa such as Nemipteridae and Carangidae (Figures 6.1d and 6.1f, respectively), and in a few minor taxa (Appendix D), has consistently been dominated by the smallest grade. This condition may indicate that a significant share of the catch of these taxa was relegated to trash.

The trip receipt records, as mentioned in Chapter 3, do not have information on trash fish catch which cannot therefore be included in calculations of CPUSE. The ommission of trash fish catch is crucial to the modelling process in that estimates of CPUSE derived solely from edible catch would be a biased indication of stock abundance if the proportion of total catch relegated to trash has changed over time, either, from growth over-fishing or shifts in gear selectivity.

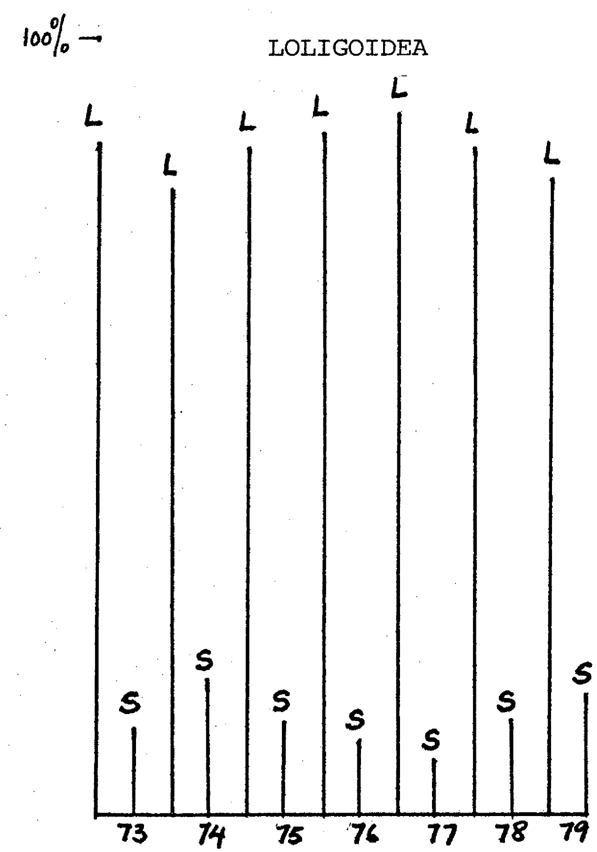
It was possible to obtain the trash fish share of total FT CPUE by the combined use of panggu records and pure data from trip receipt records. All FT panggu decompose total sales into sales from edible as well as trash fish. A subset of the FT panggu also lists the weight of trash fish sold. This information together with estimates of the average annual price of total edible catch for the FT fleet

FIGURE 6.1: GRADE COMPOSITION OF THE SAMPLED CATCH OF VARIOUS MAJOR TAXA, 1973 - 1979

(L - Large, M - Medium, and S - Small)



(a)



(b)

FIGURE 6.1: GRADE COMPOSITION OF THE SAMPLED CATCH OF VARIOUS MAJOR TAXA, 1973 - 1979

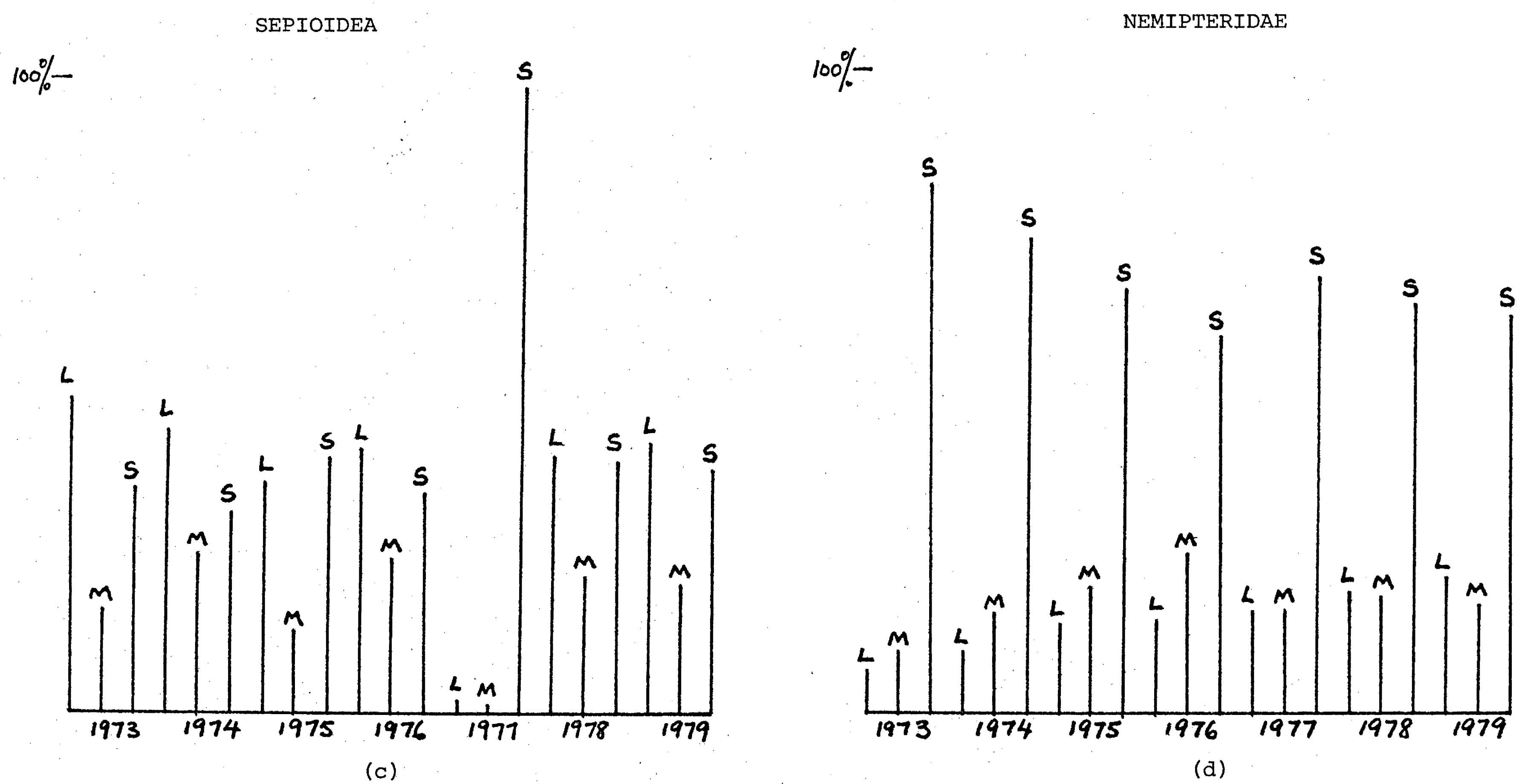
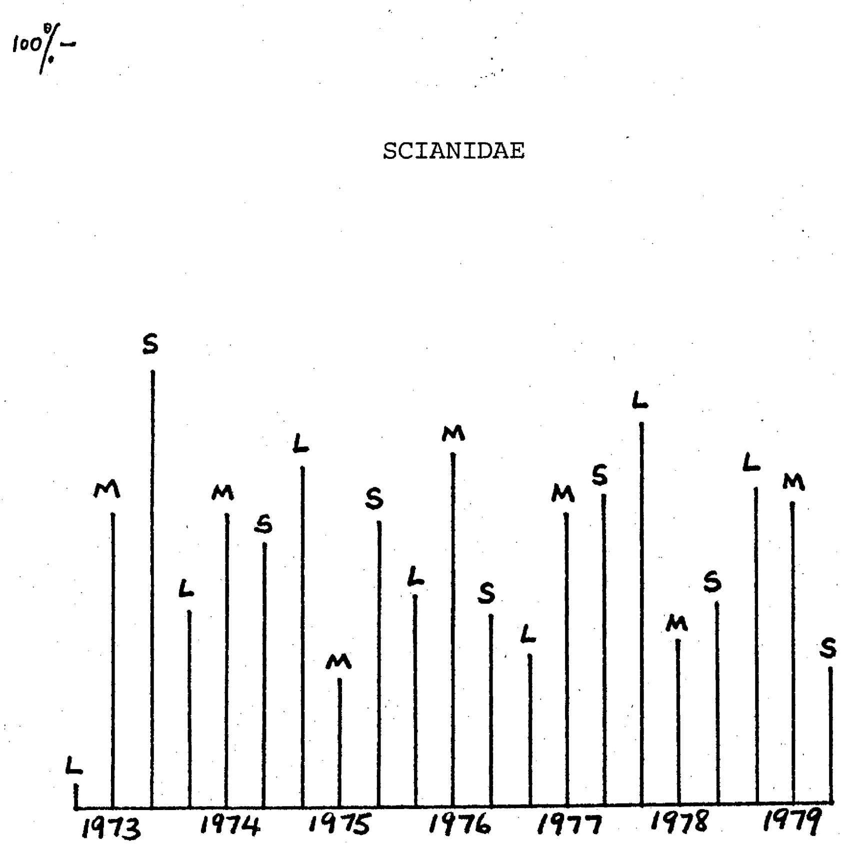
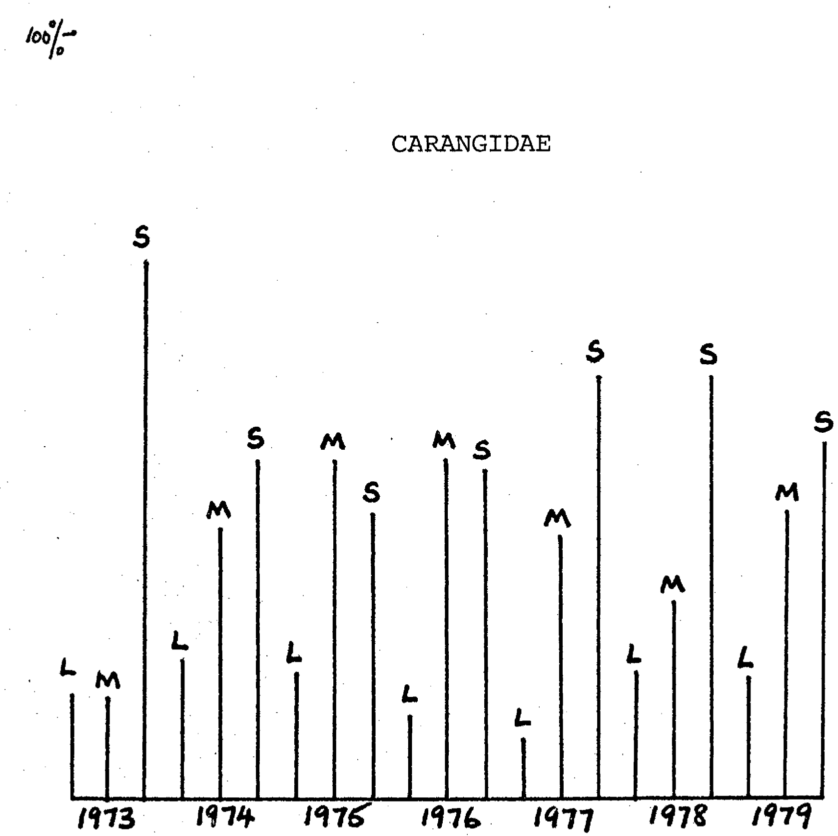


FIGURE 6.1: GRADE COMPOSITION OF THE SAMPLED CATCH OF VARIOUS MAJOR TAXA, 1973 - 1979



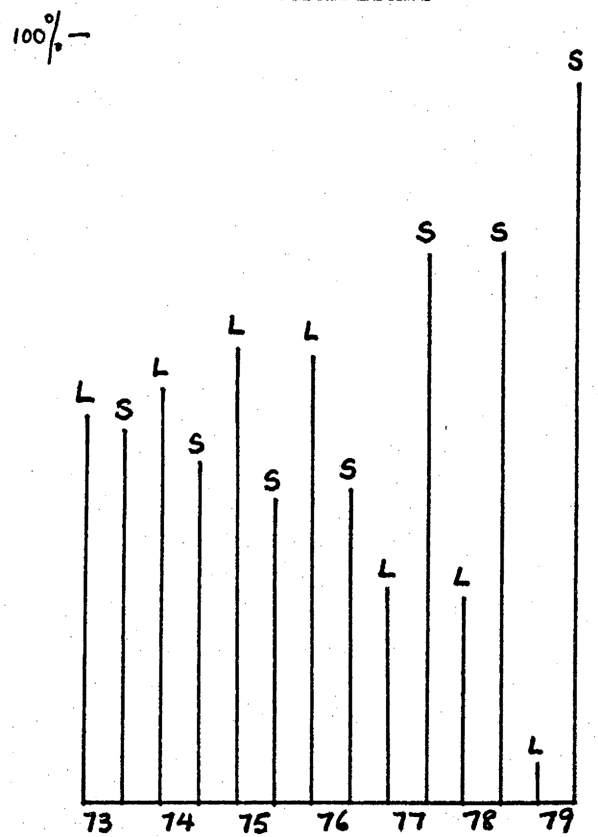
(e)



(f)

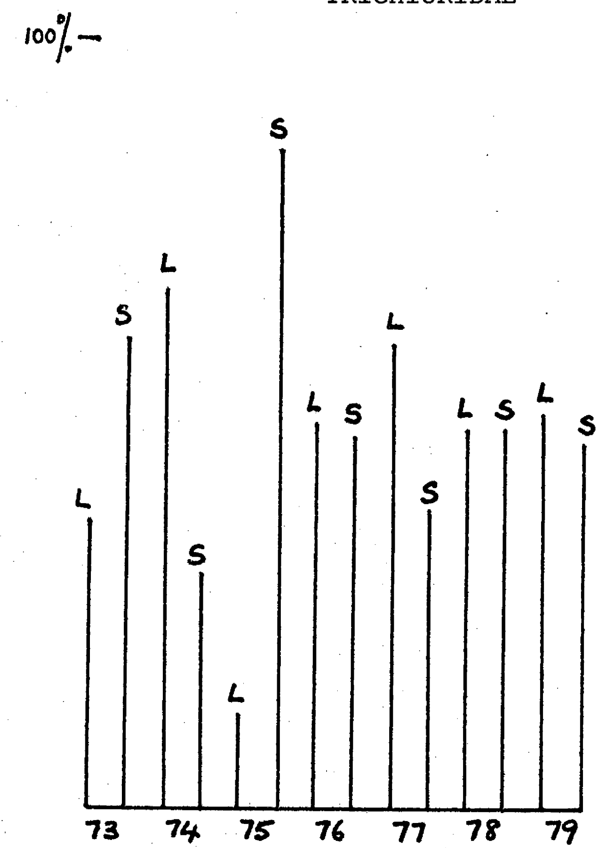
FIGURE 6.1: GRADE COMPOSITION OF THE SAMPLED CATCH OF VARIOUS MAJOR TAXA, 1973 - 1979

FLATFISHES



(g)

TRICHIURIDAE



(h)

from the trip receipt records (see section 3), enabled the decomposition of the average annual FT CPUE of total catch into edible and trash fish.

As shown in Table 6.1, the trash fish share of FT fleet CPUE is very large, averaging 56% over the 1973 - 1979 period. However, the trash fish share has not changed to any significant degree. The relatively large trash fish share of total CPUE which only fetches a low price, is a good indication that a substantial portion of immature or non-recruited individuals are harvested. This would be consistent with general opinion, based on published data and, upon which a major case for prohibiting or limiting trawler activity has been predicated. However, the trash fish share of total CPUE has not changed to any significant degree. Such stability of the trash fish share of FT CPUE over time indicates that on the whole there has been no trend of decrease in the size of individuals harvested to less than edible size. It is therefore submitted that notwithstanding popular opinion, more research is necessary before the relative economic efficiency of trawlers with respect to growth over-fishing can be assessed properly. CPUSE estimates should not be biased by the exclusion of trash fish catch.

6.2.2 Environmental Determinants

Production and catch rates are undoubtedly affected by random changes in environmental parameters. This is particularly true of the more r-selective semi-pelagic taxa. As will be seen shortly, the large degree of variation in annual CPUSE, often unrelated to effort, suggests that variation in environmental factors is at least as important a determinant of population abundance as fishing mortality.

TABLE 6.1 : PROPORTION OF MEAN ANNUAL CPUE OF FT FLEET MADE UP BY EDIBLE AND TRASH FISH

	1973	1974	1975	1976	1977	1978	1979
Edible Catch	42	43	47	45	44	43	47
Trash Fish	58	57	53	55	56	57	53
Total	100	100	100	100	100	100	100

Source : *Panggu* and Trip Receipt Records

The simple surplus production models discussed in Chapter 4 are deterministic. Smith (1978 and 1980) has developed a stochastic surplus production model based upon the logistic curve which estimates the uncertainty of the production process. Unfortunately the 10 year data set in this study is too short for the Smith model which requires the estimation of 5 coefficients and would leave too few degree of freedom. The best alternative herein employed presents the variance of estimated MSY and associated level of effort and CPUSE as a measure of uncertainty in the production process.

6.2.3 Closed and Single Unit Populations

The surplus production models must be used on fish populations which are distinct, self-sustaining units fully enclosed within the fishing area. These models and any model using catch and effort data cannot apply if a fish stock exhibits changes in size as a result of persistent immigration and/or emigration disproportionate to its abundance.

The taxa exploited by the trawl fishery appear to be concentrated within the offshore boundaries of trawler activities. Table 6.2 shows the known sublittoral range and distribution of the taxa and the number of species per taxon commonly caught. This information is collected from trawl surveys conducted in waters off Peninsular Malaysia and supplemented by life history descriptions in Scott (1959) and FAO (1974). Only 10 taxa are found in significant concentrations beyond depths of 60 meters; of these only 3 (Nemipteridae, Gerridae and Carangidae) exhibit increasing abundance with increasing depth. Another 4 taxa (Ariidae, Lutjanidae, Rachycentidae and Scomberomoridae) are found in large concentrations

TABLE 6.2 : SUBLITTORAL RANGE AND NUMBER OF COMPONENT SPECIES

		Range [1],[3] meters	No.of Species [2]	Depth [4] meters
I. Demersal				
A. Zoobenthic Prey				
Prawns	3	0 - 30	8	D
B. Large Zoobenthic Feeders				
Rays	17	20 - 40	6	D
C. Brachyura	15	5 - 30	2	D
D. Prey Fishes				
1(a) Gerridae	6	21 - 60	3	I
(b) Nemipteridae	7	30 - 60	6	I
2. Flatfishes	11	0 - 30	3	NK
3(a) Mullidae	26	30 - 50	5	D
(b) Leiognathidae	27	30 - 50	1	D
E. Intermediate Predators				
1(a) Scianidae	8	10 - 40	1	D
(b) Bramidae	19	10 - 20	3	D
(c) Ariidae	22	10 - 60	2	N
(d) Pomadasyidae	24	30 - 40	3	D
(e) Lutjanidae	25	40 - 60	7	N
2. Sepioidea	4	10 - 30	1	D
3(a) Sphyraenidae	14	20 - 50	2	N
(b) Sharks	21	10 - 60	2	NK
(c) Drepanidae	29	20 - 40	1	D
F. Large Predators				
1. Serranidae	20	30 - 40	3	N
2. Muraenesoadae	23	30 - 40	2	D
II.Semi-Pelagic				
G. Prey				
1(a) Kembong	1	21 - 30	2	D
(b) Clupeidae	5	20 - 40	1	D
2(a) Dorosomidae	18	10 - 20	1	D
(b) Engraulidae	28	30 - 60	2	D
H. Intermediate Predators				
1. Loligoidea	2	31 - 60	1	D
2. Carangidae	10	50 - 60	6	I
I. Large Predators				
1(a) Chirocentridae	13	30 - 40	1	D
(b) Rachycentridae	30	30 - 60	1	N
2(a) Trichiuridae	12	20 - 40	1	D
(b) Scomberomoridae	16	30 - 60	2	N
III. Misc. Catch	9	n.a.	n.a.	n.a.
IV. Pooled spp.	31	n.a.	n.a.	n.a.

[1] Depth at which component species are concentrated.
[2] No. of species commonly caught.
[3] 60 meters is the maximum range beyond which the survey vessels did not operate.
[4] Relationship between taxa abundance and depth over its given range.
I - increasing
D - decreasing
N - no relationship
NK - not known
n.a. - not applicable

in depths beyond 60 meters but there is no discernible relationship between abundance and depth. The distribution pattern of these 7 taxa strongly suggests that they do not represent populations fully enclosed within the fishing area. Migration of offshore stocks of these 7 taxa may distort CPUSE as a measure of abundance. The remaining 23 taxa are either not found beyond depths of 60 meters or, if they are, their abundance decreases with increased depth. Such a distribution pattern seems to indicate a low probability of inter-mingling but non-available offshore stocks.

The migratory movement of demersal and semi-pelagic species has, with the exception of Rastrelliger spp. (Kembong), been little studied in the South East Asian region. No definitive statement can therefore be made of the major semi-pelagic species except in the case of the Kembong. Tagging studies undertaken in the Gulf of Thailand suggest that the migratory patterns of the demersal species is not extensive [Chomjurai and Bunnag,1970].

Rastrelliger neglectus, the only species that makes up the Kembong taxon, has been well studied in Thailand since the early 1960s where the species was found to exhibit seasonal migration between the northern breeding grounds and the western feeding grounds [Dhebtaranon and Chotiyaputta,1972]. The migratory behaviour of Rastrelliger neglectus has been suspected of causing fluctuations in availability which distort catch and effort data as a measure of the relative abundance of the stocks [Hongskul,1972].

Although the Rastrelliger neglectus has been less well studied in Malaysia, available information indicates that the Kedah/Perlis purse seine and trawl fisheries exploit a single cohort stock which breeds and feeds in water near Pulau Langkawi which exhibits no marked migratory pattern [Chong and Chua,1974].

6.2.4 Age Groups Exploited

The determinants of population growth, the individual growth, recruitment and natural mortality, are known to be affected by the age composition of the population. Any change in the range of age classes exploited will eventually result in a shift in the population growth process and invalidate the use of a surplus production model.

The technological change that has taken place in the trawl fishery since 1969 may have altered the age class selectivity of the fleet. The replacement of the Thai trawl with the high opening net might have resulted in increased catchability of larger individuals. With the present state of information, the existence and extent of alteration in age class selectivity are matters of speculation. However, the very small mesh size in the cod end of all trawl types reduces escapement rate to near zero and facilitates the efficient harvest of all age classes.

6.2.5 Independent Populations

The inability to directly consider the inter-relationships amongst the exploited taxa is undoubtedly the most serious limitation of a simple surplus production model. As seen in Chapter 4, the web of interactions in a tropical ecosystem is typically complex and the aquatic communities exploited by the Kedah/Perlis trawl fishery are no exceptions. Unfortunately the inter-relationships are unknown and there are no analytical tools or empirical basis to identify and upon which to model them. It was therefore necessary to assume that the taxa represent independent populations and to use a surplus production model as a first step to comprehending the dynamics of exploited fish stocks. The surplus production function for pooled taxa will be estimated and this should to some extent include the inter-relationships of the component species.

6.3 Choice of Surplus Production Model

Three surplus production models, the Schaeffer-Gulland, Fox and Genprod models, were outlined in Chapter 4. Schnute's alternative model that has already been mentioned is based on the logistic curve which estimates the following specified equation with ordinary least squares (OLS).

$$\mathrm{Ln}\,(U_t/U_{t-1}) = r + q\,\frac{(E_{t-1} + E_t)}{2} + \frac{r}{qk}\,\frac{(U_{t-1} + U_t)}{2}$$

where

U = CPUSE

E = effort

r = natural growth rate

q = catchability coefficient

k = carrying capacity of the environment

t = year

The main advantages of the Schnute model are its greater theoretical plausibilty and its direct provision of r and q estimates. All other models require q to be independently estimated - an exceedingly difficult task. Unfortunately the Schnute model requires the estimation of three coefficients with N-1 observations (N being the number of observations) thus reducing the accuracy of the estimates.

The Genprod model suffers from the same draw-back as the Smith and Schnute models, requiring the estimation of 5 coefficients although its variable functional form makes it apparently superior. Moreover, many studies that have used the Genprod model (for example, Hongskul,1975 and Fox,1975) have found that the optimal functional form closely approximates the fixed form Gompertz and logistic curves. Fox [1975, p.33] concluded that in cases of short time series, as is the case here, it is better to estimate the fixed form models and choose that which provides the superior fit.

In view of the short time series of CPUSE and effort data in this study, the Genprod and Smith models were not used. Instead, the Schnute, Schaeffer-Gulland and Fox models were estimated for each taxon using annual and moving average effort series. The 'best fit' model, (see footnote 1) , was used to estimate the equilibrium yield function and MSY, and associated effort and CPUSE levels. The equilibrium yield function estimated by the 'best fit' model was also tested for accuracy by a validation run in the fish stock simulator.

The formula for estimating the values and variance of MSY, associated effort and CPUSE levels, and coefficients of the equilibrium yield function for each model is given in Appendix D, Tables 1 - 3. The formula (based on Fox,1975) used to obtain independent estimates of the average catchability coefficients necessary for the Schaeffer-Gulland and Fox models is given in Table 4 of Appendix D.

6.4 Results of Surplus Production Models

The results of the 'best fit' surplus production models are summarised in Tables 6.3, 6.4 and 6.5. Table 6.3 summarises the

(fn: opposite)

TABLE 6.3 : RESULTS OF REGRESSIONS FOR 'BEST FIT' SURPLUS PRODUCTION MODEL FOR EACH TAXON

	Tax. No.	Mod. [1]	R^2	F [2]	a	Var.(a)	b	Var.(b) [3]	Var.(a, b) [4]	q	D-W
I. Demersal											
A. Zoobenthic Prey											
Prawns	3	5	0.354	1.1448	4.0118	0.2319	+0.005446	0.2591	-0.2427	n.a.	1.387
B. Large Zoobenthic Feeders											
Rays	17	4	0.631	16.381**	35.636	49.01	-0.15714	15.075	-26.76	0.00603	0.672*
C. Brachyura	15	5	0.32	3.758#	4.2572	0.962	-0.02404	1.5381	-2.064	0.014136	1.215
D. Prey Fishes											
1(a) Gerridae	6	2	0.191	1.658	2.4291	180.9	+0.000244	226.39	-191.5	n.a.	1.266
(b) Nemipteridae	7	2	0.29	3.288	3.6652	139.5	+0.24746	186.25	-155.8	n.a.	1.5
2. Flatfishes	11	3	0.491	7.716*	4.0811	0.07823	-0.01046	0.14187	-0.10301	0.00559	0.652*
3(a) Mullidae	26	4	0.524	8.803*	19.776	17.12	-0.2905	95.865	-35.87	0.018097	0.889*
(b) Leiognathidae	27	4	0.555	9.956*	15.725	17.03	-0.18437	34.144	-23.86	0.019747	0.546*
E. Intermediate Predators											
1(a) Scianidae	8	1	0.523	4.294*	2.4886*	n.c.	-0.02084	0.00817	n.c.	0.02214	1.816
(b) Bramidae	19	2	0.413	5.627*	12.0313	8.184	-0.07873	11.010	-9.188	0.00897	0.958
(c) Ariidae	22	3	0.802	32.426**	4.3165	0.6132	-0.06784	1.4195	0.46671	0.03318	0.724*
(d) Pomadasyidae	24	5	0.509	8.288*	1.9539	0.1244	-0.013722	0.2272	0.15696	0.00619	1.27
(e) Lutjanidae	25	5	0.512	8.385*	2.1421	0.3526	-0.01926	0.4424	-0.3781	0.01394	1.967
2. Sepioidea	4	1	0.634	6.6#	1.9245	n.c.	-0.02083	-0.00751	n.c.	0.01083	1.75
3(a) Sphyraenidae	14	5	0.506	8.198	3.3571	0.05139	-0.031806	0.11203	0.06807	0.08433	0.897
(b) Sharks	21	1	0.312	1.359	1.2683	n.c.	-0.12685	0.08173		0.00909	2.12
(c) Drepanidae	29	5	0.556	10.033*	3.9457	2.898	-0.11047	12.163	5.876	0.01105	2.566
F. Large Predators											
1. Serranidae	20	4	0.608	12.426*	17.881	10.89	-0.09809	7.743	-8.924	0.011938	0.678*
2. Muraenesoadae	23	5	0.743	23.158**	3.6369	0.2855	-0.02821	0.3435	-0.30397	0.01779	1.476
II. Semi-Pelagic											
G. Prey											
1(a) Kembong	1	3	0.49	7.674*	6.3181	0.058987	-0.017175	0.3844	-0.1365	0.023678	1.92
(b) Clupeidae	5	2	0.452	6.607*	169.77	0.1562	-2.4157	8822	-34.55	0.012147	1.05*
2(a) Dorosomidae	18	5	0.621	13.078**	4.2556	0.1264	-0.02995	0.6857	0.279778	0.022212	1.329
(b) Engraulidae	28	2	0.228	3.657#	-0.0926	0.09526	+0.0145	57.673	-0.2175	n.a.	0.903*
H. Intermediate Predators											
1. Loligoidea	2	4	0.712	19.781**	14.8324	330.5	+1.4367	1043	-549.7	n.a.	2.122
2. Carangidae	10	2	0.053	0.448#	29.971	31.27	-0.04795	51.33	-33.68	n.a.	0.524*
I. Large Predators											
1(a) Chirocentridae	13	3	0.786	29.444**	4.3368	0.04157	-0.020913	0.1485	-0.07455	0.017356	2.42
(b) Rachycentridae	30	2	0.307	3.544	1.936	0.5843	-0.04272	5.148	0.01606	0.01454	1.482
2(a) Trichiuridae	12	2	0.485	7.545*	-7.829	137.7	+0.77173	789.34	-314.4	n.a.	1.74
(b) Scomberomoridae	16	5	0.834	40.128**	1.427	0.01932	+0.0164	0.06096	-0.03384	n.a.	2.161
III. Misc. Catch	9	2	0.72	20.598**	87.898	0.152	-0.68593	228.4	-182.3	0.0202	1.167
IV. Pooled spp.	31	5	0.557	10.05*	7.462	0.039395	-0.009011	0.0808	-0.05392	0.008164	0.921*

n.a. = not applicable because of incorrect sign of coefficients or poor fit of hypothesised relationships.
** = significant at 1% level of confidence
* = significant at 5% level of confidence
# = significant at 10% level of confidence
[1] 1 = Schnute Model
2 = Schaeffer-Gulland Model
3 = Fox Model
4 = Schaeffer-Gulland Moving Average Model
5 = Fox Moving Average Model
[2] All models have 1,8 degree of freedom except the Schnute Model which has 1,6.
[3] Var.(b) is multiplied by 10,000.
[4] Var.(a,b) is multiplied by 100.

TABLI 6.4 : SUMMARY STATISTICS FROM VALIDATION RUN OF FISH STOCK SIMULATOR [1]

		1	2	3	4	5
		Av. Cat.	Std. Dev. Cat.	% Mean Error	Std. Dev. Error	Corr.
I. Deneral						
A. Zoobnthic Prey						
Prawns	3	n.c.	n.c.	n.c.	n.c.	n.c.
B. Larg Zoobenthic Feeders						
Rays	17	7.57	5.99	1.8	5.03	0.950
C. Bracyura	15	11.82	5.56	-3.0	5.65	-0.204
D. Prey Fishes						
1(a) Geridae	6	n.c.	n.c.	n.c.	n.c.	n.c.
(b) Nemipteridae	7	n.c.	n.c.	n.c.	n.c.	n.c.
2. Flatfishes	11	28.47	6.76	-4.2	3.05	-0.894
3(a) Mulidae	26	8.91	7.88	5.7	4.50	-0.929
(b) Leognathidae	27	2.84	2.54	10.6	0.67	-0.967
E. Intermediate Predators						
1(a) Sdanidae	8	48.42	36.87	4.1	22.54	0.798
(b) Bnmidae	19	5.47	2.67	-17.6	1.49	0.844
(c) Aiidae	22	12.15	11.69	-24	5.07	0.924
(d) Pomadasyidae	24	3.17	2.02	2.5	1.05	0.893
(e) Lujanidae	25	2.07	1.39	-121	0.98	0.845
2. Sepiidea	4	35.41	13.11	-8.8	11.56	0.577
3(a) Sphyraenidae	14	17.62	9.12	3.4	4.12	0.903
(b) Shrks	21	4.88	1.92	-3.7	1.36	0.708
(c) Depanidae	29	0.31	0.29	51.6	0.02	0.363
F. Larg Predators						
1. Serranidae	20	6.57	3.51	5.8	1.81	0.869
2. Murenesoadae	23	3.96	3.69	-50.3	2.49	0.973
I. SemiPelagic						
G. Prey						
1(a) Kembong	1	329.83	156.67	-2.2	117.22	0.664
(b) Clupeidae	5	75.44	56.45	-12.7	55.82	0.201
2(a) Drosomidae	18	23.68	12.24	-3.8	7.57	0.787
(b) Egraulidae	28	n.c.	n.c.	n.c.	n.c.	n.c.
H. Intermediate Predators						
1. Lolgoidea	2	n.c.	n.c.	n.c.	n.c.	n.c.
2. Carngidae	10	n.c.	n.c.	n.c.	n.c.	n.c.
I. Lare Predators						
1(a) Cirocentridae	13	29.03	12.31	-36.2	7.63	0.850
(b) Rchycentridae	30	0.26	0.27	-261.6	0.65	-0.898
2(a) Tichiuridae	12	n.c.	n.c.	n.c.	n.c.	n.c.
(b) Somberomoridae	16	n.c.	n.c.	n.c.	n.c.	n.c.
III. Mic. Catch	9	33.17	13.74	-18.9	7.71	0.844
IV. Pooed spp.	31	776.47	142.29	-12.7	140.29	0.559

[1] With X_t as recorded CPUSE and Y_t as simulated CPUSE, these statistics are calculated from the following:

Col. 1, $(\Sigma X_t)/T = \bar{X}$

Col. 2, $[(\Sigma X_t - \bar{X})^2/T]^{1/2} = Sx$

Col. 3, $[(\Sigma X_t)/T - (Y_t)/T] / (X_t)/T = \%E$

Col. 4, $[(\Sigma X_t - Y_t)^2/T] = S_E$

Col. 5, $[\Sigma X_t - \bar{X})(Y_t - \bar{Y})/T] / [\Sigma X_t - \bar{X})^2/T]^{1/2}[(Y_t - \bar{Y})^2/T]^{1/2} = corr_{xy}$

n.c. = not calculated because of insignificant fit to surplus production model.

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TABLE 6.5 : ESTIMATES OF MAXIMUM SUSTAINABLE YIELD AND ASSOCIATED LEVELS OF EFFORT AND CPUSE FOR ALL TAXON AND ASSOCIATED CATCH AND EFFORT LEVELS IN 1978

	Tax. No.	MSY (m.t.)	Var. MSY (m.t.)	Catch (m.t.)	Opt. Effort days	Var. E (days)	Tot. Eff. 1979 (days)	Opt.CPUSE (kati per 1000days)	CPUSE '78 (kati per 1000days)	Over-fishing
I. Demersal										
A. Zoobenthic Prey										
Prawns	3	n.c.	n.a.	6098	n.c.	n.c.	131.554	n.c.	85.81	n.r.
B. Large Zoobenthic Feeders										
Rays	17	1222.2	220.3	563	113387	7446	262.638	10.88	3.85	**
C. Brachyura	15	1080.5	441.6	399	41593	9737	113.789	25.98	6.46	**
D. Prey Fishes										
1(a) Gerridae	6	n.c.	n.c.	1263	n.c.	n.c.	145.779	n.c.	17.05	n.r.
(b) Nemipteridae	7	n.c.	n.c.	2789	n.c.	n.c.	133.632	n.c.	49.61	n.r.
2. Flatfishes	11	1259.5	127.1	1271	95578	12165	111.042	21.78	21.04	-
3(a) Mullidae	26	203.6	46.5	75	34038	1260	33.725	9.89	1.49	**
(b) Leiognathidae	27	202.8	43.4	40	42645	3816	65.989	7.86	0.99	**
E. Intermediate Predators										
1(a) Sciaenidae	8	2030	n.c.	2138	56204	n.c.	223.179	59.70	24.63	**
(b) Bramidae	19	278.1	103.5	309	76508	3446	121.987	6.02	4.71	**
(c) Ariidae	22	245.8	169	154	14739	915	58.74	27.56	6.97	**
(d) Pomadasyidae	24	114.4	14.11	134	72876	8950	158.021	2.60	1.66	**
(e) Lutjanidae	25	98.4	26.8	72	51924	1411	162.103	3.13	0.97	**
2. Sepioidea	4	1468.4	n.c.	2336	52546	n.c.	176.198	46.19	23.54	**
3(a) Sphyraenidae	14	442.7	n.c.	911	52534	n.c.	183.539	13.39	11.42	*
(b) Sharks	21	348.8	n.c.	293	69762	n.c.	122.696	5.0	4.43	**
(c) Drepanidae	29	172.21	139.96	14	9052	1010	82.284	19.02	0.51	**
F. Large Predators		792.6						22.91		
1. Serranidae	20	493.0	118.4	436	91147	4701	194.992	8.94	4.21	**
2. Muraenesoadae	23	299.6	97.36	136	34555	2605	145.264	13.97	1.71	**
II. Semi-Pelagic										
G. Prey										
1(a) Kembong	1	7185.2	1208.7	7752	58222	7430	54.468	204	226.31	-
(b) Clupeidae	5	1804.5	1355.6	1960	35139	16801	55.039	84.89	56.06	**
2(a) Dorosomidae	18	523.9	64.03	566	33394	3264	69.257	25.93	14.68	**
(b) Engraulidae	28	n.c.	n.c.	31	n.c.	n.c.	68.264	n.c.	1.01	n.r.
H. Intermediate Predators										
1. Loligoidea	2	n.c.	n.c.	5453	n.c.	n.c.	75.929	n.c.	116.98	n.r.
2. Carangidae	10	n.c.	n.c.	2284	n.c.	n.c.	103.002	n.c.	27.731	n.r.
I. Large Predators										
1(a) Chirocentridae	13	813.7	51.17	765	47817	3116	78.182	28.13	17.28	**
(b) Rachycentridae	30	59.7	6.41	16	23411	2610	36.040	2.55	0.70	**
2(a) Trichiuridae	12	n.c.	n.c.	1257	n.c.	n.c.	50.829	n.c.	37.62	n.r.
(b) Scomberomoridae	16	n.c.	n.c.	581	n.c.	n.c.	71.576	n.c.	12.82	n.r.
III. Misc. Catch	9	1703.5	84.15	1505	64072	1971	107.168	43.95	24.47	**
IV. Pooled spp.	31	42988.5	5771	50151	110975	1225.4	110.983	640.35	806.72	-

results of the CPUSE and effort regression while Table 6.4 presents the summary statistics from the validation run of the fish stock simulator. Table 6.5 gives the value and variance of the MSY and associated levels of effort and CPUSE.

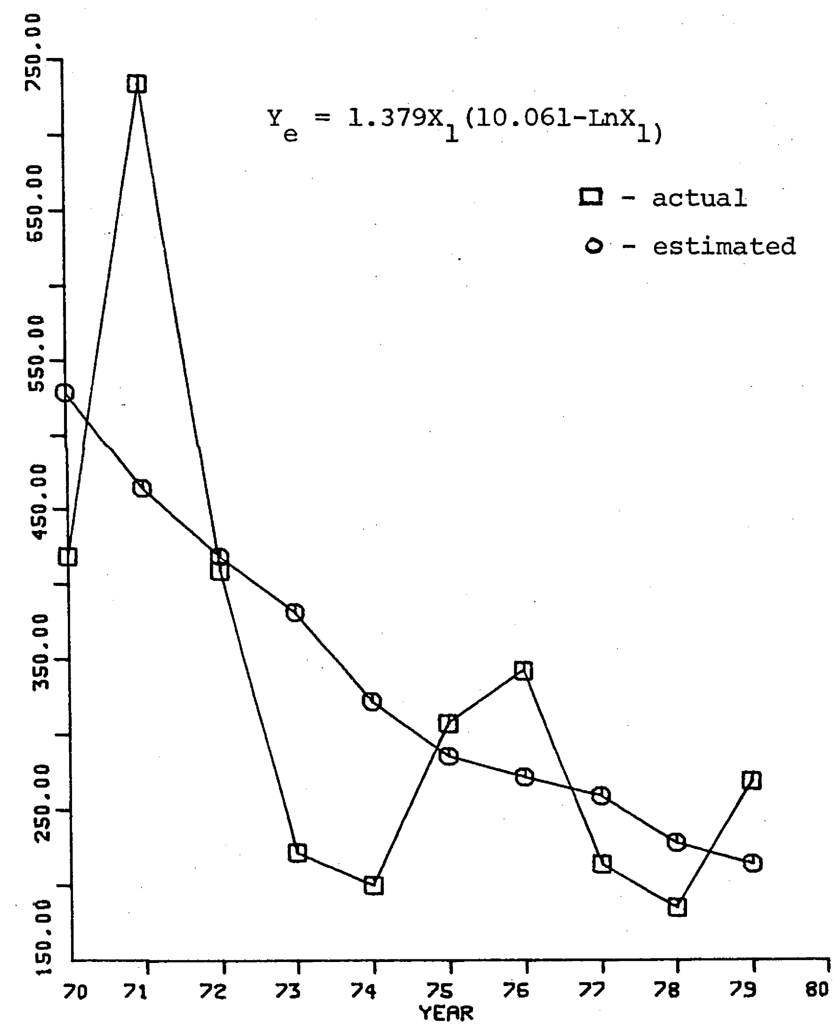
As expected, the simple surplus production models do not provide a very accurate representation of the population dynamics of the individual taxon. Only 21 taxa, including pooled species, exhibited a significant negative relationship between CPUSE and effort (Table 6.3) and the models only fitted 6 of the 12 major taxa accurately.

Kembong

The Fox model does seem to describe the production process of the Kembong taxon which is the most important taxon, by weight and by value, to the fish trawlers. The regression of CPUSE with effort is significant at a 5% level of confidence with a D-W statistic of 1.92. However, the overall fit is somewhat poor with $R^2 = 0.49$ (Table 6.3). The reason for the loose fit is readily apparent from Figure 6.2. Although CPUSE has on the average declined with increased fishing effort, there have been considerable fluctuations in CPUSE which are probably the result of variation in recruitment success. The high CPUSE in 1971 may nevertheless also be a fault of the standardisation process used to compare the trawl survey and trip receipt data sets. The equilibrium yield function shown in Figure 6.2 does not supply a very tight tracking of the actual CPUSE $corr_{xy} = 0.66$. On the average, the fluctuations in CPUSE appear to cancel out such that the percentage mean error of estimated CPUSE is only -2.2% (Table 6.4).

The Kembong taxon (if the validity of the CPUSE estimates is accepted) appears to have been exploited at or marginally below its

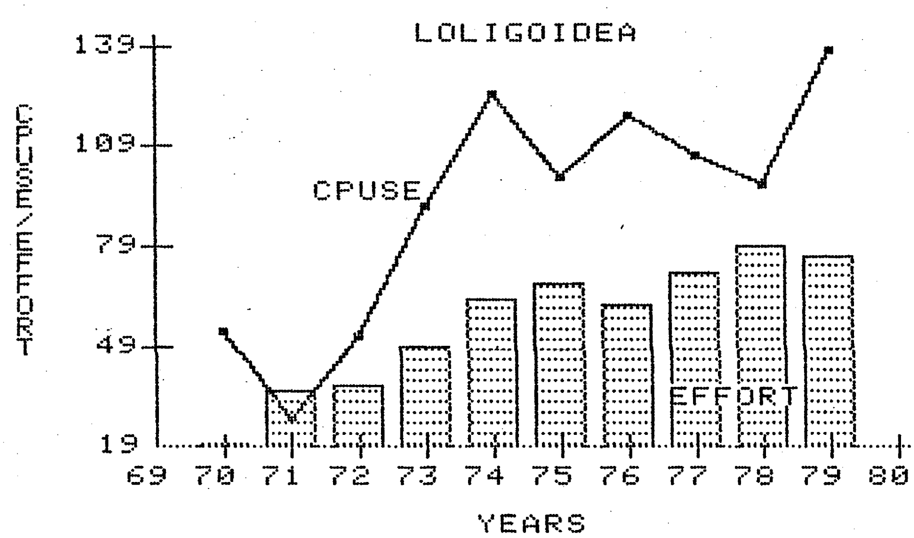
FIGURE 6.2: KEMBONG: PARAMETERS OF THE FOX MODEL AND RESULTS OF VALIDATION RUN



Y = yield

X = biomass

FIGURE 6.3: LOLIGOIDEA: CPUSE AND STANDARDISED EFFORT
1969 - 1979



MSY in 1978 - 1979. The MSY is estimated to be 7,185.2 metric tonnes (m.t.) with an associated level of effort and CPUSE of 58222 standard days (s.d.) and 204 katis per standard day (k/s.d.) respectively. During the 1978 - 1979 period the average annual catch of Kembong is estimated to have been approximately 7,752 m.t. with a CPUSE of 226.31 k/s.d. and a total effort of 54,468 s.d.

Loligoidea

In the 1970 -1979 period Loligoidea or Squid exhibited a very significant positive relationship between CPUSE and effort (Table 6.3), both of which increased with time (Figure 6.3). Gulland (1972) and Pauly (1979) found a similar pattern of increasing catch rate of Squid over time in the Gulf of Thailand despite the higher levels of fishing intensity there. Gulland attributed the phenomenon to a decline in predators and to the low catchability of semi-pelagic Squid by trawlers using the Thai trawl. Pauly (1979) essentially agreed with this prognosis but also suspected that the success of the Squid stocks was related to their being r-strategists.

All these factors are probably important in explaining the positive time trend of the CPUSE of Squid in the Kedah/Perlis trawl fleet. The demersal intermediate and large predators as well as a few of the semi-pelagic predators have shown significant declines in CPUSE between 1970 and 1979. These declines could indicate reduced predation on the Squid stock. The sharp increase in Squid CPUSE from 1971 to 1974 is a result of the increased catchability of the stock resulting from the introduction of the high opening trawl.

Prawns

Here there was no significant relationship between CPUSE and effort (Table 6.3). The apparent insensitivity of prawns to fishing effort was not completely unexpected in view of the small sample size from which the CPUSE was estimated and the poor relationship between CPUSE and effort reported in the similarly exploited prawn fisheries of Sabah in East Malaysia [Simpson and Chin,1978]. It is also known that environmental factors dominate in the determination of the growth of prawn stocks [see Chapter 3].

The concern mentioned in Chapter 5 that the relative harvest rate of the reported prawn categories making up the prawn taxon may have changed is not substantiated by Table 6.6. Tiger prawns increased slightly as a percentage of total prawn catch, mainly at the expense of white prawns, but this trend is statistically insignificant.

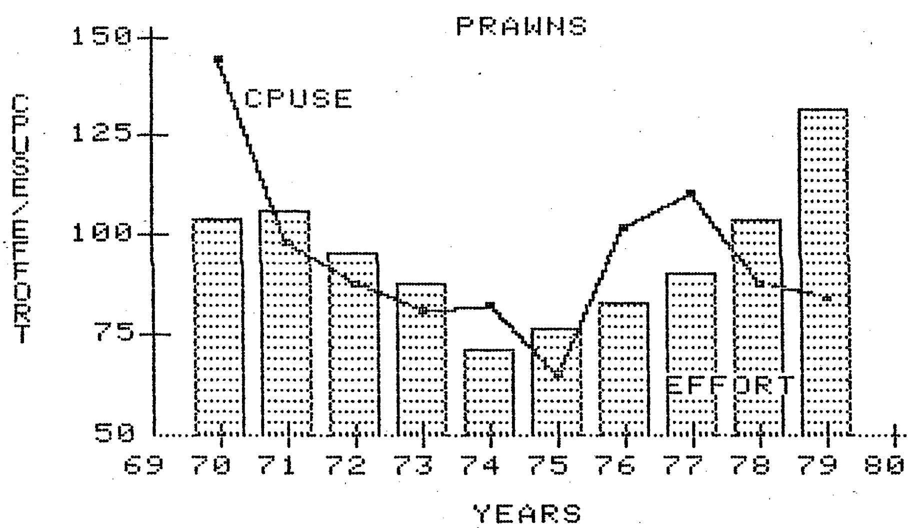
The sharp decline in fishing intensity between 1971 and 1974 (Figure 6.4) that resulted from technological change may have contributed to the continued vitality of the prawn stocks. As has been seen in Chapter 5, fish trawlers used a prawn net over 60% of days at sea before the introduction of the high opening net. With the Thai trawl replaced by the high opening net, the use of the prawn trawl decreased to the extent that total standardised fishing effort decreased from 106,172 s.d. in 1971 to 74,707 s.d. in 1974. After 1974 total prawn fishing effort increased steadily with the inflow of small prawn trawlers. The hiatus in prawn effort may well have provided the prawn species time to recuperate. Decline in predation may also have counteracted the effect of fishing mortality.

TABLE 6.6 : DISTRIBUTION OF TOTAL PRAWN CATCH BY REPORTED PRAWN CATEGORY

	1975	1976	1977	1978
White Prawns	43	34	35	30
Banana Prawns	19	26	22	26
Tiger Prawns	32	35	41	40
Sand Prawns	6	5	2	4
Total	100	100	100	100

Source : Trip Receipt Records

FIGURE 6.4: PRAWNS: CPUSE AND STANDARDISED EFFORT
1969 - 1979



Sepioidea

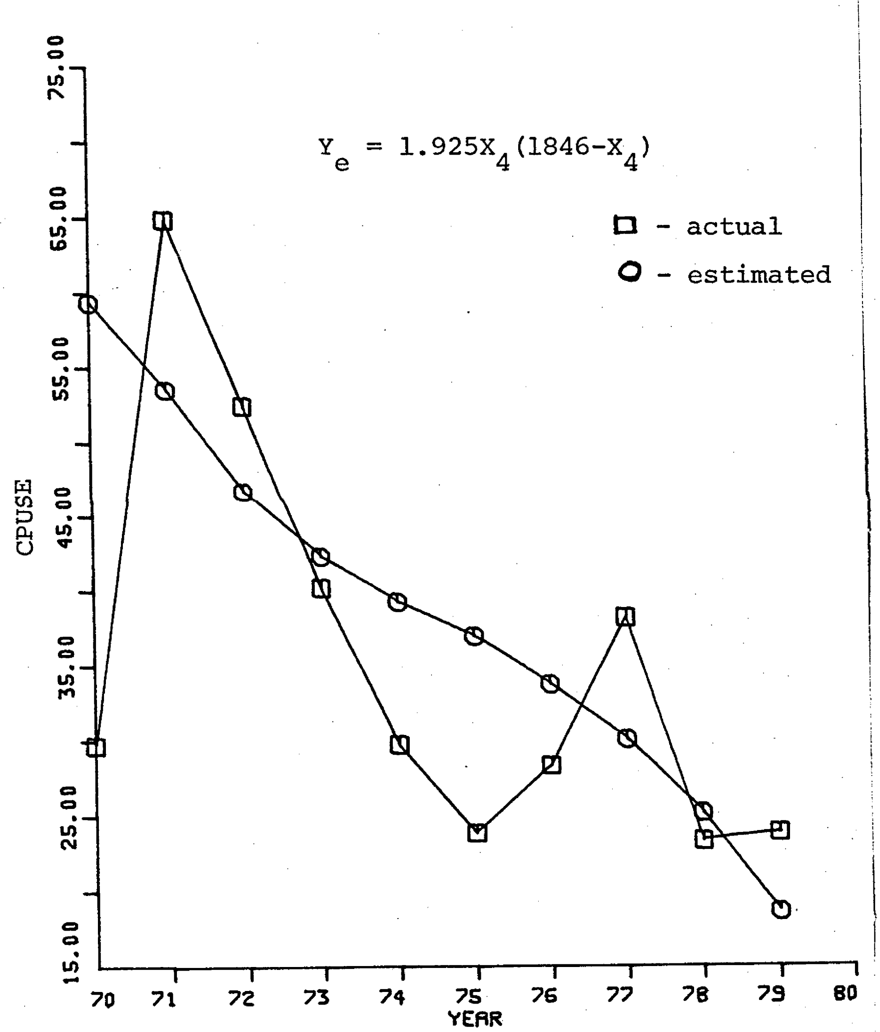
Sepioidea or Cuttlefish is a highly priced cephalopoda concentrated well within depths of 40 meters and is harvested mainly by prawn trawlers. The Schnute model provided a good fit to the Cuttlefish CPUSE and effort data with the F statistic significant at a 5% level of confidence, the R^2 equal to 0.634 and D-W = 1.75 (Table 6.3). Despite this, the equlibrium yield function shown in Figure 6.5 does not provide a close tracking of actual CPUSE for reasons similar to those of the Kembong taxon. Large fluctuations in Cuttlefish CPUSE were probably related to recruitment success. The $corr_{xy}$ was found to be only 0.577. However, the fluctuations tended to cancel out such that the percentage mean error (%E) was only -8.8% (Table 6.4).

The Cuttlefish stock is, from the results of the surplus production model, significantly over-fished (Table 6.5). The MSY of Cuttlefish is estimated to be 1,468.4 m.t. which in concert with an associated level of effort of 52,546 s.d., produces a CPUSE of 46.19 k/s.d.. During the 1978 - 1979 period, the approximate harvest of Cuttlefish averaged 2,336 m.t. which is significantly higher than the estimated MSY. However, this high total catch was only achieved with a very high fishing intensity of 176198 in 1979 and is accordingly not sustainable.The result is that the approximate 1978 - 1979 average CPUSE was only 23.54 k/s.d. as compared to an estimated maximum of 46.19 k/s.d.

Clupeidae

The Schaeffer-Gulland model gave a substantially significant fit to the CPUSE and effort data on the Clupeidae taxon. The regression was significant at a 5% level of confidence but the R^2 and D-W

FIGURE 6.5: SEPIOIDEA: PARAMETERS OF THE SCHNUTE MODEL AND RESULTS OF VALIDATION RUN



Y = yield

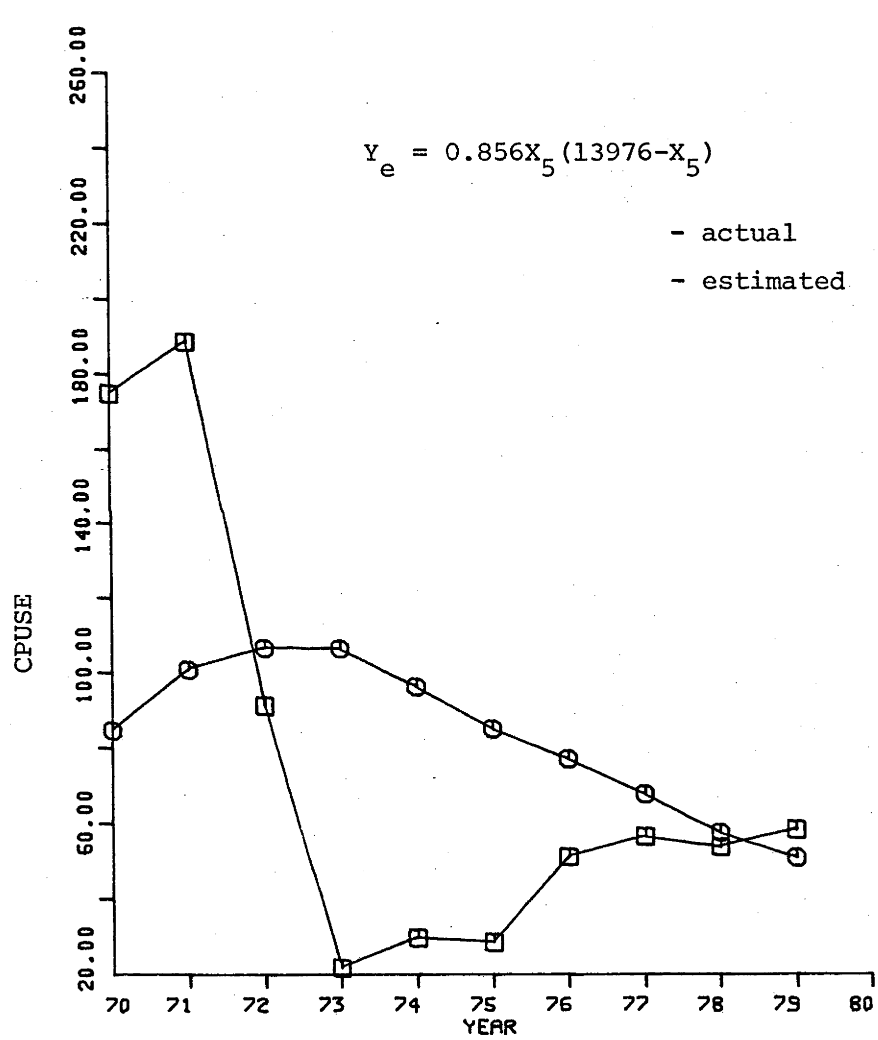
X = biomass

statistics were low at 0.452 and 1.05 respectively (Table 6.3). The reason for the poor overall fit is evident from Figure 6.6. The CPUSE data are composed of two incongruous data sets : derived from the trawl surveys of 1970 and 1971 and estimated from the trip receipt records of 1973 - 1979. Even if the characteristic volatility of Clupeid stocks is taken into consideration, it is doubtful that the abundance of the Clupeidae taxon declined by over 90% between 1971 and 1973 as appears to be the case. A more tenable explanation for the difference in CPUSE levels is a very poor catch of Clupeids during the 1974 trawl survey which led to an inaccurately low estimate of the relative fishing power of the survey vessel and a high estimate of the 1970 and 1971 CPUSE. The continuous increase in CPUSE between 1973 and 1979 is even more inconsistent with the above results. Both these anomalies caste doubt on the validity of the CPUSE data and their results.

The positive trend in Clupeid CPUSE is probably a result of the increased catchability of the high opening net. Although the Clupeid stock is concentrated in depths of less than 40 meters (and abundance thereafter decreases with increased depth), it is a semi-pelagic stock. It can be expected that the fish trawl captains who practised targeting and who had enhanced skills with the high opening net would increase the catchability of semi-pelagic taxa. This is likely to be the case even though the low priced Clupeid may not be the direct target of the fish trawlers.

The equilibrium yield function (Figure 6.6) naturally does not track the actual CPUSE closely with $corr_{xy} = 0.201$ and %E = -12.7% (Table 6.4). In view of the low credibility of the CPUSE and effort data, little reliance can be placed on the estimated MSY and

FIGURE 6.6: CLUPEIDAE: PARAMETERS OF THE SCHAEFFER-GULLAND MODEL AND RESULTS OF VALIDATION RUN



Y = yield

X = biomass

associated effort and CPUSE levels which indicate that the taxon was exploited beyond the level of maximum production by 1978 - 1979 (Table 6.3).

Gerridae and Nemipteridae

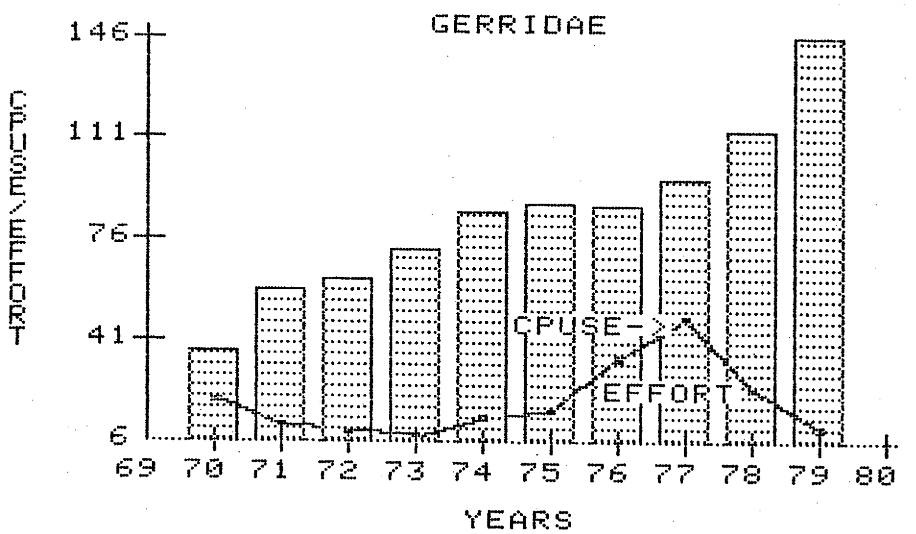
The CPUSE for the Gerridae and Nemipteridae taxa have a positive but statistically insignificant relationship with effort (Table 6.3) and time (Figure 6.7a and b). The variable and positive time trend in the catch rates of these taxa is inspite of very high initial levels of fishing effort followed by a rapid growth rate.

It is difficult to explain the apparent insensitivity of these taxa to fishing mortality. Pauly (1978) and Gulland (1972) found them to have declined sharply with increased effort in the Gulf of Thailand. As both taxa are demersal, the introduction of the high opening trawl and associated skills should not be significant factors. Besides, targeting of these economically low value taxa is unlikely. Perhaps the answer lies in large inter-mingling Gerridae and Nemipteridae stocks in the muddy untrawlable area which replace the inshore stocks as they are depleted. The more thorough coverage of the populations by the Thai fleets in the Gulf of Thailand could explain the different Thai experience.

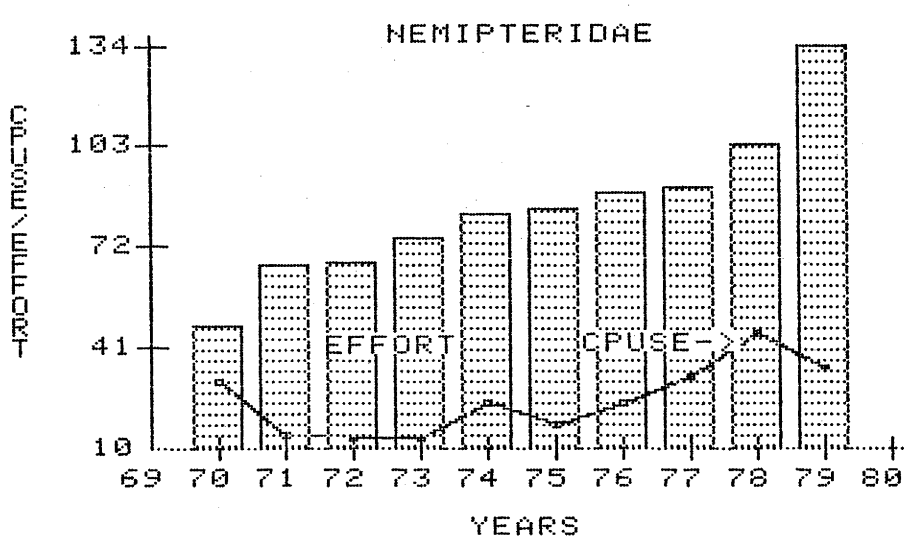
Scianidae

The Schnute model fitted the Scianidae or Jewfish taxon. The regression was significant at a 5% level of confidence with R^2 = 0.523 and D-W = 1.816 (Table 6.3). Jewfish CPUSE fluctuated considerably over the 1970 - 1979 period. Nonetheless, the equilibrium yield equation as shown in Table 6.4 and Figure 6.8,

FIGURE 6.7: GERRIDAE (a) AND NEMIPTERIDAE (b): CPUSE AND STANDARDISED EFFORT, 1969 - 1979

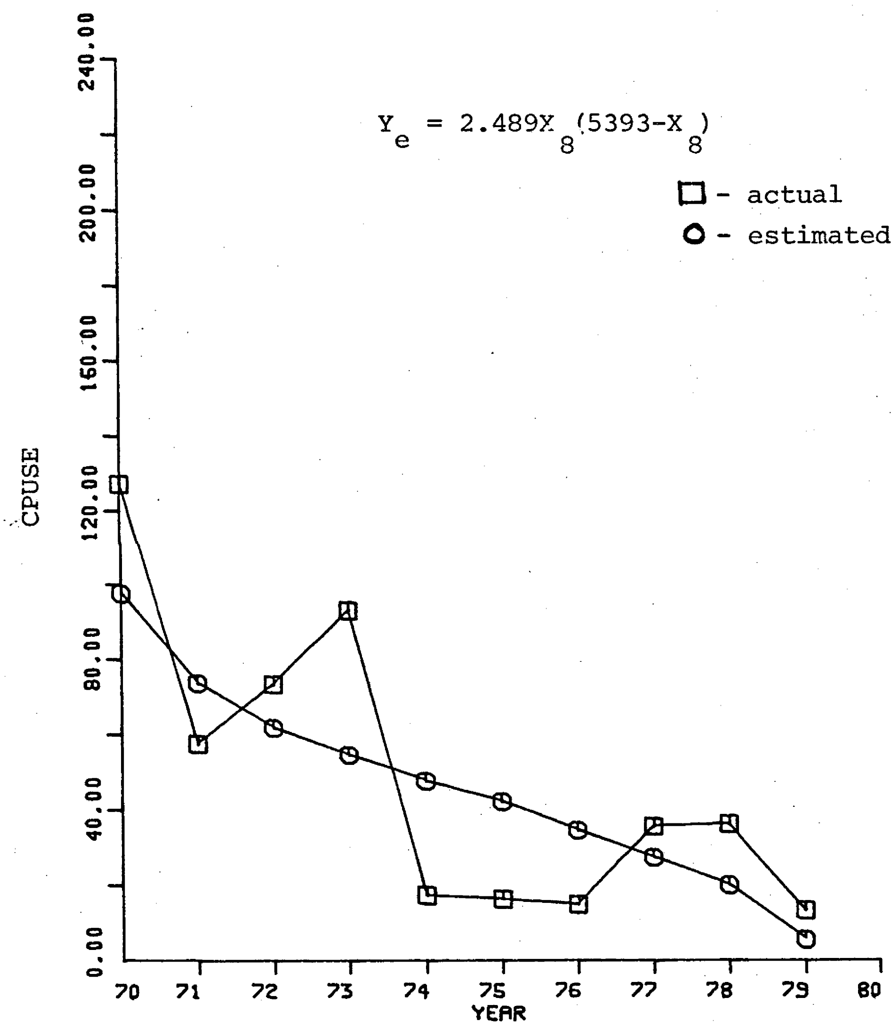


(a)



(b)

FIGURE 6.8: SCIANIDAE: PARAMETERS OF THE SCHNUTE MODEL AND RESULTS OF VALIDATION RUN



Y = yield

X = biomass

tracked actual CPUSE quite well; $corr_{xy}$ = 0.798 and %E = 4.1%.

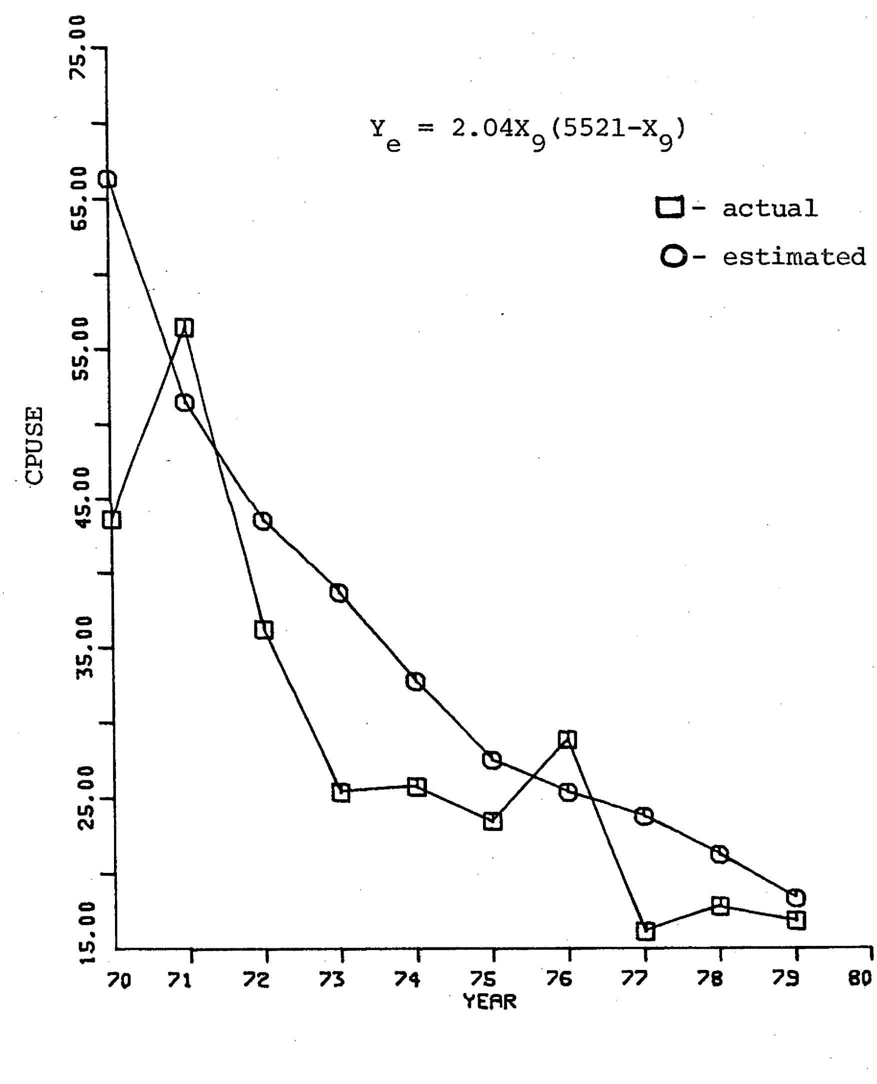
According to Table 6.5 the Jewfish stock was over-fished in 1978 - 1979. The estimated MSY is 2,030 m.t. which is equivalent to the approximate average Jewfish catch in 1978 - 1979. However, fishing effort in 1978/79 was 223,179 s.d. in constrast to the estimated 56,204 s.d. required to achieve MSY. The high actual fishing effort produced an approximate average 1978 - 1979 CPUSE of 24.63 k/s.d. as compared with an estimated maximum of 59.7 k/s.d..

Miscellaneous Catch

The Schaeffer-Gulland model fitted the CPUSE and effort data of the Miscellaneous catch reasonably. The regression is significant at a 1% level of confidence with an R^2 of 0.72 although the D-W statistic is rather low at 1.167, indicating positive autocorrelation (Table 6.3). The equilibrium yield function (Figure 6.9) gives a close tracking of actual CPUSE especially considering the large decline in catch rate of Miscellaneous catch in 1972 - 1973 and 1975, with
$corr_{xy}$ = 0.844 and %E = -18.9 (Table 6.4).

The Miscellaneous catch have been estimated to have been biologically over-fished in 1978 - 1979 (Table 6.5). The MSY of Miscellaneous catch was estimated to be 1,703.5 m.t. with associated levels of effort and CPUSE of 64072 s.d. and 43.95 k/s.d. respectively. MSY and optimum CPUSE are in excess of the corresponding approximate average 1978 - 1979 levels even after taking into consideration variance of the estimates.

FIGURE 6.9: MISCELLANEOUS CATCH: PARAMETERS OF THE SCHAEFFER-GULLAND MODEL AND RESULTS OF VALIDATION RUN



Y = yield

X = biomass

Carangidae

The positive trend over time of Carangidae CPUSE in Figure 6.10 is clearly a product of the shift from demersal to semi-pelagic stocks associated with the switch from the Thai trawl to the high opening net. The Carangidae taxon comprises of 8 species (see Chapter 5) all of which are semi-pelagic except Selayang and Cermin which are found close inshore and are easily accessible to demersal gear. In 1969, prior to the adoption of the high opening trawl, the Carangid catch was of, predominantly, the inshore species, Selayang, Cermin and Rambai (Table 6.7). Cincaru, Pelata and Selar Kunning were caught only incidentally. By 1973 no catch of Selayang was reported probably because it was classified under the miscellaneous species or under some other Carangid species, and the catch rate of Cermin was significantly reduced. However, the high opening trawl which was in wide use by 1973 had allowed access to the semi-pelagic Cincaru, Pelata and Selar Kunning stocks all of which had high catch rates. Continued increase in the catch rates of the semi-pelagic species, the Cincaru and the Pelata, in particular, was probably the result of heightened targeting by the trawlers just as the purse seine fleet was at the same time targeting for Carangid species (Table 5.17). Improved skills of both captain and crew with the high opening net too would have contributed to increased catchability of these species.

Flatfishes

The 'best fit' surplus production model, the Fox model, fitted the Flatfish taxon poorly. The regression, though significant at a 5% confidence level, had a $R^2 = 0.491$. Positive autocorrelation seems

FIGURE 6.10: CARANGIDAE: CPUSE AND STANDARDISED EFFORT
1969 - 1979

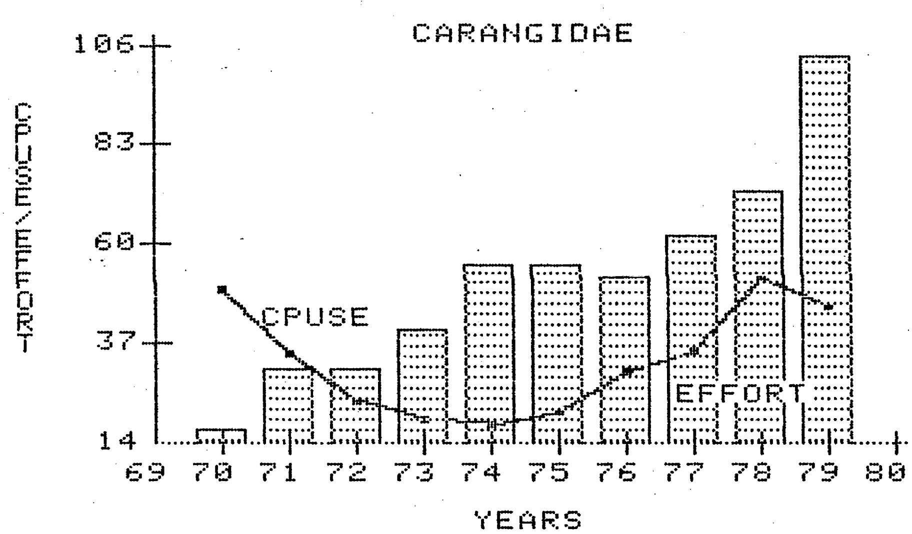


TABLE 6.7 : AVERAGE ANNUAL CATCH PER FISH TRAWLER FOR EACH REPORTED CARANGID SPECIES

Scientific Name	Malay Name	1969	1973	1974	1975	1976	1977	1978	1979
Megalaspis Cordyla	Cincaru	3.1	24.2	22.1	18.5	30.6	46.0	122.5	205.1
Selar Crumenophthalmus	Pelata	2.5	7.1	7.9	18	55.3	46.9	53.1	123.7
Selaroides Leptolepis	Selar Kunning	2.5	18.5	18.5	50.6	56.4	50.7	22.2	44.8
Caranx Armatus	Rambai	15.2	21.1	19.3	19.7	14.1	17.3	35.4	21.9
Caranx Ferdau	Demudok	2.1	1.2	3.0	4	1.9	1.6	3.6	2.6
Chorinemus Lysan	Talang	0.4	0.6	0.8	0.7	0.3	0.7	0.6	0.9
Alectis Indica	Cermin	6.3	1.1	0.8	0.5	0.3	0.2	0.4	0.2
Decapterus Russeli	Selayang	20.4	0	0	0	0	0	0	0
Total		52.5	73.8	72.4	112.0	158.9	163.4	237.8	399.2

Source : Trip Receipt Records

highly probable from the very low D-W statistic of 0.652 (Table 6.3). Nevertheless the equilibrium yield equation provided an excellent tracking of actual CPUSE with $corr_{xy}$ = 0.894 and %E = -4.2% (Table 6.4 and Figure 6.11).

The Flatfish taxon appears to have been exploited at its MSY by 1978 - 1979 which is rather surprising in view of the very high fishing intensity channeled to its component species. The MSY is estimated to be 1,259.5 m.t. with associate levels of effort and CPUSE of 95,578 s.d. and 21.78 k/s.d. respectively. All these estimates are statistically equivalent to their corresponding approximate average 1978 - 1979 levels (Table 6.5).

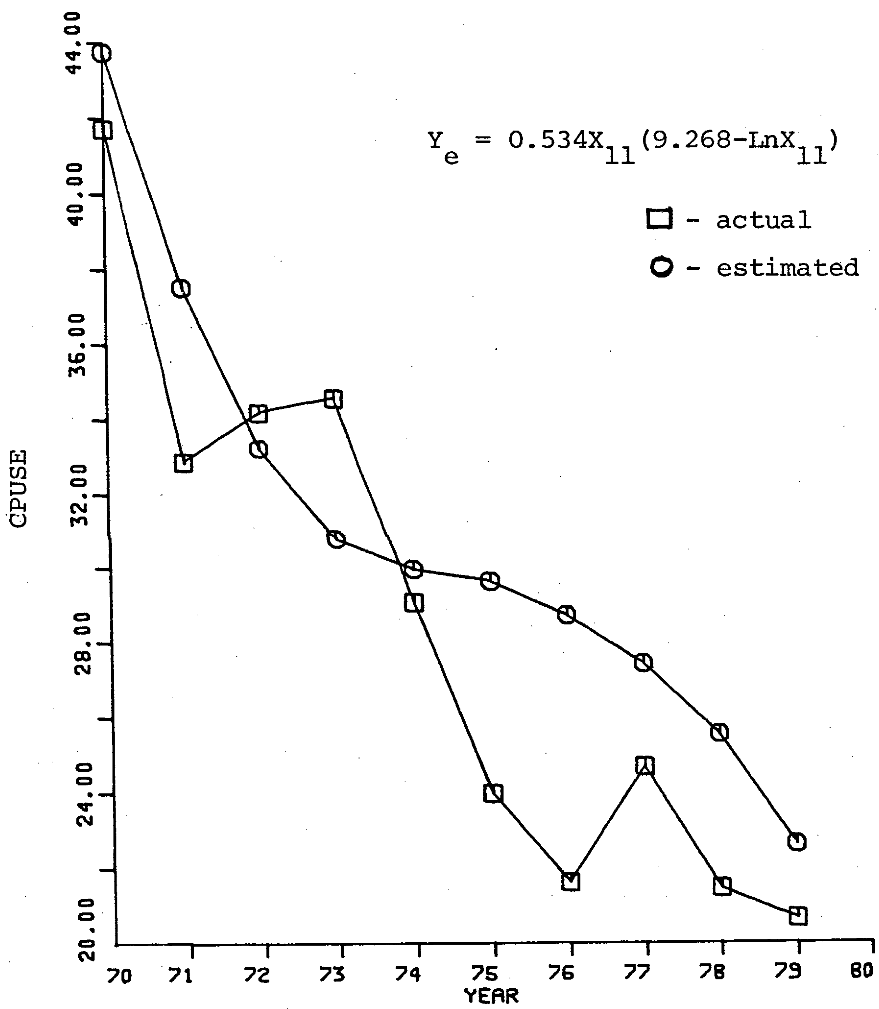
Trichiuridae

The CPUSE of Trichiuridae or Ribbon fish collapsed in 1975 - 1976 but subsequently recovered and, on the average, increased in 1970 - 1979. This positive trend occured inspite of relatively high fishing intensity by fish and prawn trawlers (Figure 6.12).

The most likely explanation is a decrease in predation without a parallel decline in prey such that abundance prevails despite high fish mortality. In view of the inshore distribution of the taxon (Table 6.2), the existence of inter-mingling offshore stock is unlikely and the low economic value of the taxon argues against targeting.

The exceedingly large number of small grade individuals in the 1975 catch (Figure 6.1h) together with the low overall catch rate implies that a big proportion of the 1975 total catch may have been comprised of individuals of less than economic size.

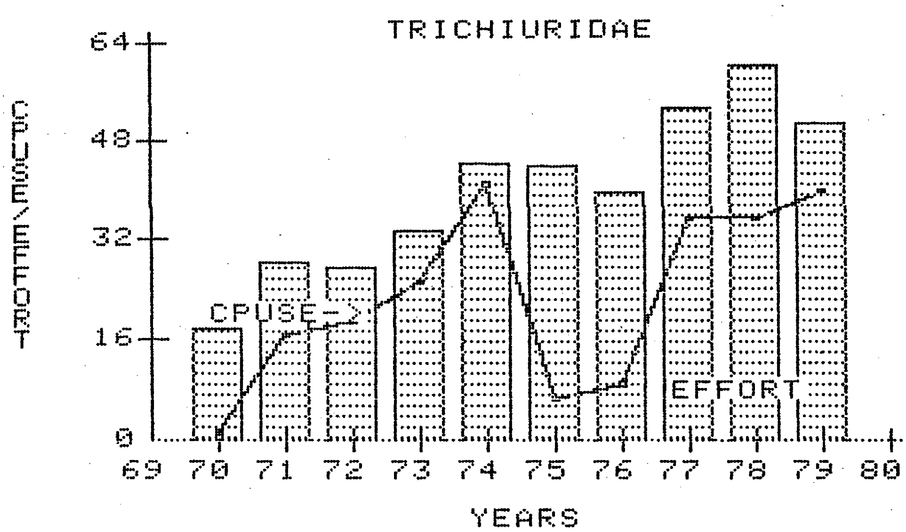
FIGURE 6.11: FLATFISHES: PARAMETERS OF THE FOX MODEL AND RESULTS OF VALIDATION RUN



Y = yield

X = biomass

FIGURE 6.12: TRICHIURIDAE: CPUSE AND STANDARDISED EFFORT
1969 - 1979



6.5 Increasing Minor Taxa

The CPUSE of Scomberomoridae and Engraulidae exhibited a significant positive relationship with effort from 1970 - 1979 (Table 6.3). Although these semi-pelagic taxa are unlikely to be primary targets of trawlers using the high opening trawl, their increased catchability and CPUSE may have been the result of targeting for other semi-pelagic species.

Indeterminant Minor Taxa

Rachycentridae and Sharks had negative but insignificant relationships between CPUSE and effort (Table 6.3). Rachycentridae is made up of a single semi-pelagic species (*Rachycentron canadus*) found at all depths without any discernible preferential concentration. The estimated CPUSE are therefore unlikely to be accurate measures of the true abundance of the population especially when the species is caught in very small quantities. Sharks, as mentioned in Chapter 5, is an aggregation of pelagic and demersal shark species which are likely to be differentially available to and affected by fishing effort. Its CPUSE as a measure of its abundance is thus open to question.

6.6 Declining Minor Taxa

The CPUSE of the remaining taxa which are primarily demersal predators, were significantly described by a surplus production model (Table 6.3). The calculated equilibrium yield equations, on the whole, gave a very close fit to the actual CPUSE (Table 6.4).

According to the estimates of MSY and associated levels of effort and CPUSE in Table 6.5, the 14 declining minor taxa are over-fished. The important implication here is that the predator species have been severely depleted as have the stocks for which the Thai trawl was intended. Decline in predator stocks naturally means, ceterus paribus, that the total equilibrium yield of prey species available to the fishing fleet increased, (see Table 5, Appendix D for the parameter values of the 'best fit' surplus production model for each of the declining minor taxa).

6.7 Biological Over-Fishing

The results of the surplus production analysis show that, contrary to all earlier studies (see Chapter 2), the stocks exploited by the Kedah/Perlis trawl fleet are, in the aggregate, not biologically over-fished (Table 6.5). Although the surplus production models were in general deficient in the evaluation of the production processes of individual taxon (mainly because of the low accuracy of CPUSE data), the results demonstrate the following which seriously throw claims of biological over-fishing into disrepute.

1. Of the 12 major taxa which contributed over 87% of the total trawl catch in 1975 - 1978, only 6 taxa had significant negative relationships between CPUSE and fishing effort. Of these, Kembong and Flatfish were exploited below or at their MSY. In the case of the Clupeidae taxon, the CPUSE data was too suspect for a sound estimate of sustainable yield. None of the remaining 6 major taxa can be said to have been exploited at or even near their MSY as of 1978 - 1979.

2. Only 20 of the 30 taxa exhibited significant and negative relationships between CPUSE and effort.

3. The semi-pelagic species which accounted for over 30% of total trawl catch during 1975 to 1979 were only available to the trawl fishery relatively recently (since 1974) following the introduction of

the high opening net and, also at a time when the then main harvestor of these species, the purse seine fleet, declined.

4. The results of the surplus production models for pooled species imply aggregate exploitation of fish stocks by the combined trawl fleet at their MSY. The MSY of pooled species estimated from the Fox model is 42,988.5 m.t. with corresponding levels of effort and CPUSE of 110,975 s.d. and 640.35 k/s.d. respectively. The approximate average 1978 - 1979 catch, effort and CPUSE for pooled species (50,151 m.t., 110,983 s.d. and 806.72 k/s.d. respectively) are all statistically equivalent to their maximum yield estimates.

CHAPTER 7

EMPIRICAL ANALYSES OF REVENUE, COSTS AND RATES OF RETURN

7.1 Introduction

Economic theory, as discussed in Chapter 4, suggests that a fishery is capable of generating rent. In this event, the returns to both vessel owners as well as the crew members would be greater than their respective opportunity costs. The common property nature of the fishery resource leads to the appropriaton, by the owners and crews, of the rent emanating from the fish resources. Supra-normal returns are thus earned. In most industries supra-normal rents would not be passed on to labour. However, the share system of allocating returns among the crew and owners in Kedah/Perlis results in the crew receiving some rent.

The more important question that arises from the potential resource rent in the Kedah/Perlis fishery is its dissipation. The accepted view of the Malaysian trawl industry is that supra-normal returns existed in the earlier years of the industry but were in the case of the FT fleet, dissipated as early as 1971 by a rapid and continuous inflow of trawlers which the ineffective barriers were unable to prevent. This accepted view, it is submitted, is contentious even though it was only after 1972 that the regime of limited entry controlled more effectively the number of trawlers, in particular the larger fish trawlers, in Kedah/Perlis. (This persisted until 1976 when political and economic pressures led to the relaxation of licence control and the ensuing inflow of small prawn trawlers.)

It is therefore proposed to describe the share system of allocation of returns practised in the Kedah/Perlis trawl fishery and to re-examine the abovementioned 'accepted view' that her resource rent has already been dissipated. The latter will be achieved by studying the rates of return earned by trawler crew members from 1969 - 1979. The obvious disadvantage of this approach is that the rates of return may not represent steady-state conditions. (This is not over-looked in Chapter 8 where a main theme is the determination of the potential economic value of the FT fleet under steady-state conditions.)

7.2 Share Allocation: Estimating Economic Parameters

a) Prices

It was explained in Chapter 3 that there are two sets of fish prices relevant to the FT fleet :ex-vessel prices and market prices. Ex-vessel prices, shown in trip receipt records, were readily provided by the cooperating FT vessel owners. The same vessel owners were, however, exceedingly reluctant to disclose records of their marketing activities and especially their prices. They realised that the overall profitability of their firms could be easily established from their market prices and they feared that their positions vis-a-vis their crew, competitors and the income tax department might be jeopardised. A representative set of market prices was also difficult to obtain because of the considerable variation over time in such prices received by the vessel owners. This was so even though catches were consigned to the same markets for the wholesale market agents offered any of a range of prices according to their ties with the vessel owners, reportedly, in a manner similar to the relationship between market agents and prawn trawl owners described in Chapter 3.

In view of the foregoing difficulties, unpublished monthly wholesale fish prices recorded by the regional Federal Agricultural Marketing Authority (FAMA) and Majuikan were used as an alternative, albeit a somewhat inferior one.

Ex-Vessel Prices

The mean annual ex-vessel price per taxon for fish trawlers using only fish trawls was calculated with the mean of ratio estimator given in equation 7.1:

$$(7.1) \qquad P^T = \sum_k \left(\frac{\sum_i \sum_j (P_{ijk} * C_{ijk})}{\sum_i \sum_j (C_{ijk})} \right)$$

where

P^T = ex-vessel price per kati

C = catch in katis

j = reported categories included in each taxon, j = 1,...n

i = months, i = 1,...12

k = vessels.

The mean annual ex-vessel prices, deflated by the Consumer Price Index (CPI) are given in Appendix E, Table 1. From these estimates, it is clear that although there has been considerable volatility in annual ex-vessel prices per taxon there has been no significant increase in these prices, at least, between 1975 - 1979. In contrast, the retail index for fresh fish products increased by over 26% in the same period. The absence of a parallel trend in ex-vessel prices can be attributed to either a decline in average size of fish landed or to an increase in market margins. But it was seen in previous discussions that, except for Kembong, Flatfishes and a few minor taxa, there was no decline in the average individual size. In the cases of a few aggregated taxa, changes in the relative share of the component species may explain the absence of an upward trend in ex-vessel prices. It would seem that the general absence of ex-vessel price increase is attributable to an increase in market margins.

Market Prices

In the market agent survey (Ques. 12), the 94 catch categories reported in the trip receipt records were divided into 5 grades (Table 7.1) on the basis of ex-vessel prices with the help of the FT enumerators. Prawns (Grade 5) were treated separately because they are marketed locally. Local prawn prices are very close to non-local prices, in part because of the large number of assemblers and the two local prawn processors, and few FT owners desire to consign their catch.

The 40 FT market agents interviewed in the market agent survey were asked to identify the primary market at which they sold or consigned each grade of catch. As expected the distance shipped was found to be an increasing function of price. Grades 1 and 2 were usually consigned to the furthest centres such as Singapore, Johore Baru, Malacca and Kuala Lumpur. Grade 3 catches went to the intermediate market centres of Ipoh and Kuala Lumpur, while Grade 4 catches were usually sold at the local Alor Star market or conveyed to Bukit Mertajam or Penang.

TABLE 7.1 : MEAN ANNUAL MARKET PRICE RATIO BY GRADE AND FOR POOLED SPECIES (1969 RINGGIT)

	Price Range	1973	1974	1975	1976	1977	1978	1979
Grade 1	above 1.75	1.323	1.387	1.308	1.308	1.393	1.365	1.252
Grade 2	1.00 - 1.74	1.325	1.241	1.418	1.301	1.507	1.536	1.545
Grade 3	0.45 - 0.99	1.326	1.379	1.587	1.405	1.423	1.456	1.498
Grade 4	0.44 - below	1.161	1.181	1.281	1.205	1.206	1.294	1.216
Grade 5	Prawns	1.142	1.112	1.199	1.163	1.158	1.199	1.201
Pooled Spp.		1.281	1.265	1.438	1.368	1.367	1.402	1.343

Source : Trip Receipt Records and FAMA and Majuikan unpublished wholesale price statistics(1973/79)

From 1969 to 1977, FAMA compiled monthly wholesale price statistics for the four major market centres in Peninsular Malaysia (i.e. Kuala Lumpur, Ipoh, Penang and Johore Baru). These statistics covered 17 species caught by the trawl fleet and each species was divided into 2 to 3 sizes : large, medium and small. Of the 94 catch categories reported in the trip receipt records, 39 (or 42%) were accounted for by these statistics. In 1976, Majuikan began to collect wholesale fish price statistics on the same species covered by FAMA and graded them similarly. Another market centre, Alor Star, was, however, included. In the calculations that follow, the Majuikan statistics are preferred for they not only included an additional important market but they are also believed to be more accurate. Majuikan also made available their unpublished estimates of marketing costs inclusive of transport, crating, ice and handling costs to each of the four major centres from Alor Star and Kuala Kedah.

The monthly market price for each of the reported categories in the secondary price statistics was estimated to be the average of the wholesale price net of marketing costs prevailing in the centres to which it is most often consigned or sold (as identified above). The average net wholesale prices in Kuala Lumpur and Johore Baru were used for Grades 1 and 2 reported catch categories. The corresponding average prices in Ipoh and Kuala Lumpur were used for Grade 3 categories and Penang prices and, whenever available, Alor Star prices were used for Grades 4 and 5 reported catch categories.

The market price for each of the remaining 55 catch categories was estimated from the market prices obtained from the secondary statistics and the trip receipt records. First the average annual market price ratio (market price/ex-vessel price) for each grade was calculated (see Table 7.1). Then the ex-vessel price for each of the remaining catch categories was multiplied by the appropriate annual market price ratio to give an estimate of market price. The complete set of market prices was subsequently employed using equation 7.1 to estimate the annual average market price per taxon for fish trawlers employing a high opening trawl. These price estimates are given in Appendix E, Table 2.

The average annual market price ratio of pooled species caught by the FT fleet irrespective of trawl type were estimated with the ratio of the means estimator, equation 7.2, and are given in Table 7.1.

$$(7.2) \qquad \overline{\overline{MM}} = \frac{\sum_i \sum_j \sum_k (P^m_{ijk} * C_{ijk})}{\sum_i \sum_j \sum_k (P^v_{ijk} * C_{ijk})}$$

where

$\overline{\overline{MM}}$ = average annual market price ratio

P^m = market price

P^v = ex-vessel price

i = months, $i = 1, \ldots 12$

j = reported catch categories, $j = 1, \ldots 12$

k = all classes of FT vessels.

Increase in Marketing Margin

The annual market price ratios by grade and for pooled species in Table 7.1 clearly show that the real increases in fish prices, illustrated by the CPI for fresh fish products, during the 1973 - 1979 period was to a large extent absorbed by the marketing section of the FT firms and not passed on to the vessel and crew. The market price ratio for pooled species and all grades, except grade 1, rose sharply in 1975 and either increased in the following years or remained at the 1975 level. The discontinuity exhibited in 1975 signified a definite shift in the distribution of total value added between the crew and vessel owner. The reason for this shift will become apparent in the later sections of this chapter.

b) Trip Revenue and Trip Costs

Gross Trip Revenue

The gross trip revenue given in the *panggu* records is net of transportation costs and ice costs incurred in transporting the catch locally from the jetty to the shipping platform. (Vessels which shipped directly from the jetty did not incur these latter transport or ice costs.) Bonus payments called *duit laut* which are payments of fixed sums by the vessel owner when the value of the catch exceeds a pre-determined amount (e.g. $300 in 1979), are also deducted. *Duit laut* is paid out immediately upon return from sea and is shared equally between crew and vessel owner. Total *duit laut* and transport and ice costs that were deducted were ascertainable from trip receipt records and are given for each FT class in Appendix E, Table 3.

Gross trip revenue is derived from two sources : fresh and trash fish sales. The surplus production model and price functions to be used in the simulation program will only generate estimates of fresh fish sales. Thus an independent estimate of trash fish sales must be obtained. Trash fish sales will be assumed to be 11%, 11% and 10% of the fresh fish sales of Classes C, D and E fish trawlers respectively, since the trash fish share of gross trip revenue in Table 7.2 shows a constant trend. Estimates are therefore representative of the average

TABLE 7.2 : PROPORTION OF GROSS TRIP REVENUE ACCOUNTED FOR BY FRESH FISH AND TRASH FISH SALES FOR THE FT FLEET (1969 RINGGIT)

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Fresh Fish	92	90	89	90	90	90	92	92	90	90	89
Trash Fish	8	10	11	10	10	10	8	8	10	10	11
Total	100	100	100	100	100	100	100	100	100	100	100

Source : Appendix E, Tables 4 - 6

proportion of trash and fresh fish sales in the 1969 to 1979 period.

The average real gross trip revenue for the FT fleet in Figure 7.1a increased sharply between 1975 - 1976 and remained at this level till 1979. A new plateau in gross trip revenue was reached in 1976 despite the parallel increase in marketing margins and no real increase in ex-vessel prices. Prior to 1976, the average gross trip revenue for the FT fleet remained relatively constant but showed a slight decline between 1972 and 1974 which was a period of high inflationary pressure in the general economy and of rapid technological change in the FT fleet.

The primary reason for the sharp increase in average gross trip revenue of the FT fleet, and its ability to sustain this level in subsequent years, was the rapid shift to more powerful vessel classes. According to the production function analysis in Chapter 5, gross trip revenue increased significantly with a shift from Class C to Class D to Class E trawlers (see Figure 7.1a). The difference in gross trip revenue between Class E and Class C trawlers was approximately 67% in 1979 and was greater in earlier years. The rapid shift to Class E trawlers beginning in 1975, as shown in Figure 5.2, together with an exceptionally good harvest brought about the marked increase in average gross trip revenue. After 1976, the high average real gross trip revenue was maintained only by the rapid increase in Class E trawlers which rose from 27% of the fleet in 1976 to 67% in 1979 and inspite of the decline in gross trip revenue for all the vessel classes.

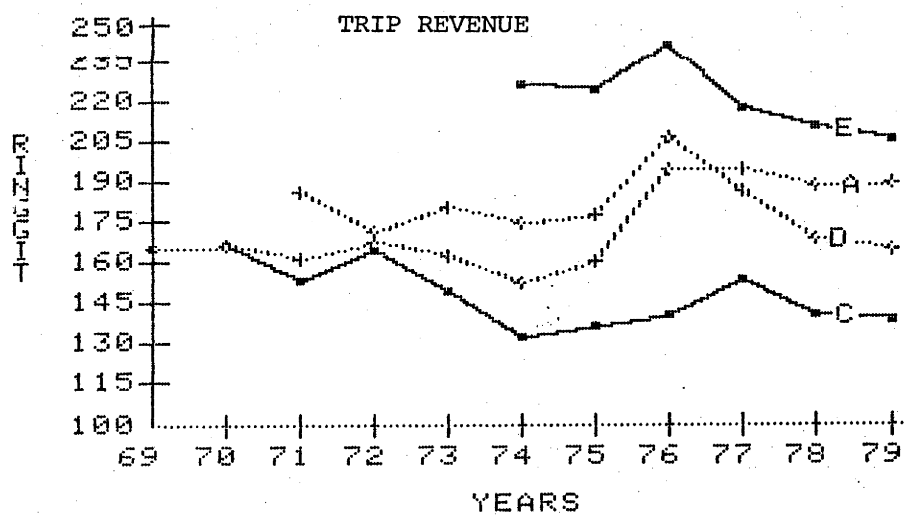
Trip Costs

The trip costs for FT and prawn trawl vessels are composed of 8

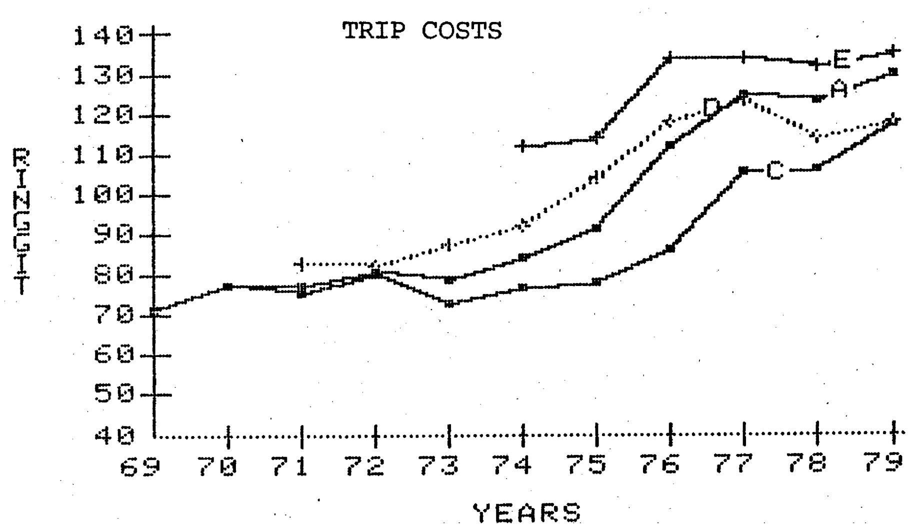
FIGURE 7.1: MEAN ANNUAL TRIP RESULTS OF THE FT FLEET: (a) TRIP REVENUE, (b) TRIP COST (c) NET TRIP REVENUE

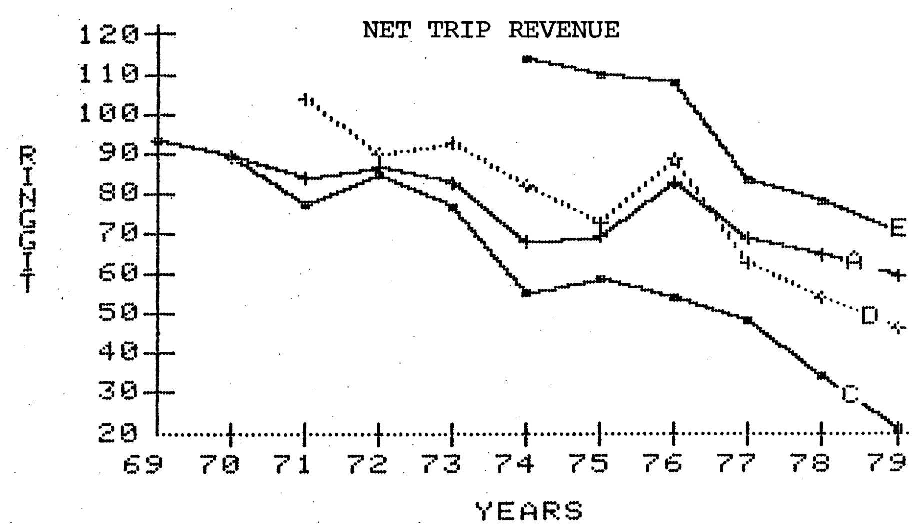
Key:

A - All Classes
C - Class C
D - Class D
E - Class E



(a)





major items from the panggu records. They are petroleum costs (diesel fuel and lubricants), food, ice, net repairs, insurance, extra crew payments, miscellaneous expenditure and co-operative commission. The average annual itemised costs, gross trip revenue and net trip revenue for each vessel-gear type in the sample are given in Appendix E, Tables 4 - 12.

The most important cost factor for all vessel-gear types was diesel consumption which was approximately 72% of total trip costs in 1979 for prawn vessel-gear types and 80% for fish trawlers.

The average annual real trip cost of the FT fleet increased swiftly between 1973 and 1976 and stabilised thereafter as shown in Figure 7.1b. Rises in diesel price in 1973 and 1976, and increased diesel consumption resulting from the shift to more powerful vessels accounted for this. Figure 7.1b shows the expected increase in running costs with larger engine class. Only in 1979 was there no significant difference between the trip costs of the FT classes. The equivalence of Class D to Class C trip costs in that year is probably the result of sampling error arising from the small sample size of Class C trawlers (i.e. 1 vessel).

Net Trip Revenue

The net trip revenue for each FT class declined continuously during the 1969 - 1979 period (Figure 7.1c). The only exception was Class D vessels in 1976 and the very large catches of that year accounted for that. The average annual rate of decline for each class was approximately 8%. Nonetheless, the more powerful vessel classes had significantly greater net trip revenue such that the average net revenue for the FT fleet declined less rapidly than the individual fleets.

SPT and PKT Fleets

In general, the gross trip revenue for the prawn vessel-gear types displayed a considerable degree of instability but no discernible decline in the 1975 - 1979 period (Tables 7.3 and 7.4). Only Class A PKT vessels showed a decline in gross trip revenue since 1975. This general pattern conforms to the results in Chapter 6.

The average annual price received by the small prawn trawlers, estimated in the same manner as that for the FT fleet, shows that a large portion of the real increase in fish prices has been passed to the vessel owners and crews. Even though these prices were obtained from only two SPT market agents and cover only a short period of time, (Table 7.5), they show a distinct increase during the 1975 - 1978 period of 7% per annum. From Table 7.5, it is also evident that the instability in gross trip revenue is from fluctuations in CPUE rather than changes in prices. The most probable explanation of the trend in Gross Revenue and CPUE shown in Table 7.5 is cyclical fluctuations in prawn biomass.

Real trip costs for prawn vessels (Tables 7.3 and 7.4) are, as mentioned above, determined largely by diesel consumption and price. Since the period covered by panggu records post-date the last diesel price increase, the average annual trip costs per prawn vessel-gear type remained unchanged over that period. A few panggu records were available for SPT vessels prior to 1976 but nothing conclusive can be made of the small number of observations. The records also reveal the importance, albeit not as distinctly as in the case of the FT fleet, of petroleum costs, and the direct increase of trip costs with engine size.

TABLE 7.3: GROSS TRIP REVENUE, TRIP COST AND NET TRIP REVENUE FOR CLASS A AND CLASS C SPT VESSELS (1969 RINGGIT)

	1972	1973	1974	1975	1976	1977	1978	1979
Class A								
Gross revenue	79.05	67.91	43.71	60.77	76.94	75.33	69.88	75.24
Trip costs	18.09	31.58	23.27	25.53	26.37	29.16	29.92	27.90
Net revenue	60.96	36.33	20.44	35.24	50.57	46.17	39.96	47.34
	(3)*	(1)*	(1)*	(10)*	(20)*	(22)*	(17)*	(15)*
Class C								
Gross revenue	n.a.	n.a.	n.a.	n.a.	112.92	101.09	101.83	118.98
Trip costs	n.a.	n.a.	n.a.	n.a.	45.33	44.23	40.89	41.26
Net revenue	n.a.	n.a.	n.a.	n.a.	67.59	56.86	60.94	77.72
	(0)*	(0)*	(0)*	(0)*	(3)*	(6)*	(5)*	(6)*

Source : Appendix E, Tables 7 and 8
* = number of observations

TABLE 7.4: GROSS TRIP REVENUE, TRIP COST AND NET TRIP REVENUE FOR THE PKT FLEET (1969 RINGGIT)

	1975	1976	1977	1978	1979
PKT Fleet					
Gross revenue	n.c.	130.89	124.31	112.62	117.93
Running cost	n.c.	48.12	53.27	52.30	56.59
Net revenue	n.c.	82.77	71.04	60.32	61.34
Class A					
Gross revenue	113.11	114.40	101.08	87.67	81.21
Running costs	38.75	39.82	38.59	39.09	39.07
Net revenue	74.36	74.58	62.49	48.58	42.14
	(4)*	(12)*	(11)*	(11)*	(7)*
Class B					
Gross revenue	87.87	112.34	113.34	109.64	117.16
Running revenue	27.71	43.63	52.26	51.73	52.50
Net revenue	60.16	68.71	61.08	57.91	64.66
	(1)*	(12)*	(12)*	(11)*	(10)*
Class C					
Gross revenue	100.61	143.76	140.45	118.02	123.39
Running costs	37.92	51.61	58.76	53.86	59.80
Net revenue	62.67	92.15	81.69	64.16	63.59
	(2)*	(18)*	(25)*	(27)*	(15)*
Class D					
Gross revenue	-	152.88	138	131.95	136.47
Running costs	-	56.54	61.53	63.34	69.39
Net revenue	-	96.34	76.47	68.61	67.08
	(0)*	(14)*	(17)*	(17)*	(11)*
Class E					
Gross revenue	-	157.57	149.94	135.86	160.46
Running costs	-	80.69	74.52	65.01	76.44
Net revenue	-	76.88	75.42	70.85	84.02
	(0)*	(1)*	(5)*	(7)*	(4)*

Source : Appendix E, Tables 9 - 12
n.c. = not calculated

TABLE 7.5 : AVERAGE ANNUAL GROSS TRIP REVENUE, CPUE AND EX-VESSEL PRICE OF POOLED SPECIES FOR SPT CLASS A VESSELS (1969 RINGGIT)

	1975	1976	1977	1978
Gross Revenue	56.73	73.39	71.73	66.80
% Change		28	-2	-7
CPUE	179.60	213.67	199.52	171.47
% Change		19	-7	-14
Average Annual Price	0.316	0.344	0.36	0.387
% Change		9	5	7

Source : Panggu and Trip Receipt Records

Given the consistency of gross trip revenue and trip costs, net trip revenue has been constant during 1975 - 1979 (Tables 7.3 and 7.4) for prawn trawlers. Surprisingly, Table 7.4 illustrates a small and often insignificant difference in average annual net revenue between PKT classes, particularly the three large C, D and E classes.

c) Rates of Return to Crew

Sources of Crew Income

A major deficiency of most studies concerned with the estimation of trawl crew income in Kedah/Perlis has been the failure to include all sources of income. In addition to his share of the lay, a trawl crew member receives bonuses for special functions and a number of payments in cash and kind. Table 7.6 gives an itemised list of all crew income sources.

FT vessel owners provide special bonuses to the primary onboard decision makers, the captain and the engineer. These payments are an additional incentive to increase profitability and a means to retain their scarce expertise. In the prawn trawl fleets, the vessel owners usually act as engineers and captains and no bonus is paid. The FT captain receives approximately 10% - 15% of the vessel or owner's share of net trip revenue each panggu. The precise proportion depends on the success of the trawler and the length of the captain's service. Engineers, who enjoy high intra and inter sectoral mobility, are guaranteed a minimum monthly wage by the vessel owner who makes up the difference between this wage and the engineer's share of the lay. An extra few ringgits a month are often given for the performance of special functions as cooking, book-keeping and diving. These extra payments are not paid directly by the owner but are included in the trip costs and shared among the entire crew.

TABLE 7.6 : MONTHLY CREW EARNINGS : FT FLEET - ALL CLASSES
(1969 RINGGIT)

YEAR	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Duit Peti [1]	10.03	15.89	14.08	14.02	14.44	11.54	15.18	12.79	13.68	13.84	17.36
Duit Laut	5.09	14.45	16.96	14.20	18.86	19.63	22.82	25.03	21.31	20.99	25.39
Makan Laut	41.80	52.05	50.68	46.21	48.03	44.94	47.82	47.70	55.63	64.08	65.30
Food	27.47	38.69	34.72	33.45	33.87	29.86	29.92	32.12	31.25	29.87	29.44
Trash Fish Comm.	14.85	15.24	17.23	17.06	17.06	16.43	18.53	17.84	19.21	15.56	16.99
Non-lay Income	99.24	136.32	133.67	124.94	132.26	122.41	134.26	135.48	141.09	144.34	154.47
Engineer's comm.	0	11.60	16.63	34.40	49.96	69.47	112.89	101.99	97.79	98.19	129.07
Cap.'s comm.	146.53	237.32	122.89	128.94	132.12	109.42	109.92	124.72	123.44	96.99	92.33
Extra crew pay.	0	0.23	1.26	1.75	1.64	1.64	2.17	2.89	2.43	2.97	3.35
No. of crew	7.1	6.4	6.6	6.5	6.2	5.9	5.8	5.8	5.6	5.5	5.4
No. of shares	8.6	8.4	8.6	8.5	8.2	7.9	7.8	7.8	7.6	7.5	7.4
Dist. system [2]	3	2	3	2	2	2	2	2	1	1	1
Lay	976.87	907.56	854.57	880.20	887.21	728.05	733.67	883.49	702.33	660.62	598.16
Ordinary crew	214.17	249.76	233.91	229.95	243.16	213.01	225.97	239.64	234.01	230.31	231.08
Cook or Bk.-keep.	214.17	249.99	235.16	231.65	244.80	214.64	228.14	243.24	236.44	233.40	234.51
Netman	271.63	306.49	285.30	282.46	298.61	258.24	271.83	307.81	280.47	273.30	269.50
Engineer	271.63	318.09	301.93	316.85	348.56	327.71	384.71	396.85	378.25	371.49	398.47
Captain	475.63	500.53	459.59	463.90	486.18	412.94	427.60	474.98	450.37	413.28	400.18

Source : Appendix E, Tables 13 - 15

[1] In the absence of records, 1970/1971 Class D is assumed to be the same as Class C; and 1972/1973 Class E is assumed to be the same as Class D.
[2] Distribution systems are 1 - 7.0, 2 - 8.0 and 3 - 9.0 shares

All crew members, irrespective of their functions, also receive cash payments as duit peti, duit laut and trash fish commissions, as well as payments in kind in the form of food and makan laut. These payments will hereinafter be collectively referred to as non-lay payments.

Non-lay payments have evolved as a means by which the vessel owners can maintain crew size and continuity and provide more specific incentives to the crew. All trawler owners (i.e.prawn and fish) give a small sum of money, called duit peti, to each crew member for each day the trawler does not go to sea for whatever reason apart from the calculation of panggu. Duit peti payments which were between $2.50 - $3.00 per day in 1979, provided the crew with a minimum monthly wage and ready cash. The vessel owners often supplement this 'retainer fee' with loans when the needs of the man are deemed worthy. Duit laut is also paid to each FT crew member immediately after each successful trip. It adds to the incentive to maintain high catch levels and provides cash daily. A trash fish commission is paid to all trawler crew to prevent their dumping at sea and as a reward for the extra effort of transferring the often putrid material to the jetty. Each panggu, the vessel owners pay the captains a fixed sum per pikul of trash fish sold which is subtracted from trash fish sales included in gross trip revenue. The captain then divides the commission equally among the crew.

Two types of non-lay payments are made in kind to each member of all trawler crews and need to be valued and included in the valuation of crew income. The vessel owners purchase all food and cooking supplies consumed by the crew while at sea. These purchases are subsequently added to the trip cost. The crew also receive food in the form of fish consumed at sea and light refreshments consumed on shore which are not included in the trip costs. However, it was very difficult to obtain accurate valuation of the additional food items which were therefore not included in the assessment of crew income. The fact remains that the crew eats three meals of fish and prawns caught at sea on board the ship the value of which is likely to exceed $20 per month per crew member.

Fish is also given to or taken by each crew member for home consumption or sale. This is called makan laut and has always been a primary source of crew income in the Malaysian large scale fishing sector. Trawler and purse seine crew members usually sell their makan laut takings to local assemblers whereas their counterparts in the small scale sector regard their makan laut primarily as a source of food. The receipts from the sales are a significant source of cash income which is, to a large extent, independent of the catch rate or lay. It was observed that the trawl crew took the same amount of makan laut irrespective of the gross trip revenue. Indeed the crew of less productive trawlers were found to take greater average quantities of makan laut in order to equalise the differential in total income, a practice which complaining trawl owners are unable to prevent effectively. Dismissal is hardly a recourse for such an established practice.

The remuneration system thus described is quite unique and may be researched further. However, such pursuit is outside the scope of this thesis. It is interesting that the share system has been the dominant means of fishermen remuneration throughout the world's marine fisheries [I.L.O., 1952]. The prevalence of the share system reflects the need to share the inherent, high production risks among the crew and entrepreneurs, and to provide direct work incentive to the crew in the face of high monitoring costs [see Sutinen, 1979,p.159]. The most interesting feature of the Kedah/Perlis remuneration system is that it is a share-plus-wage system rather than a pure share system. In the share-plus-wage system, the vessel owner absorbs more of the risks. The mixed system may have evolved in Kedah/Perlis because the crews are more risk adverse than the owners who are risk neutral or who are risk takers. Another likely, and not mutually exclusive, explanation may be that the wage component (especially makan laut) is a means by which the crews can maintain a minimum income in the face of falling revenue and administered prices.

Estimating Crew Income

The lay, (in most cases) specific commissions, extra crew and many non-lay payments are to be found in the panggu records.

The lay is calculated for all trawler types on the basis of a 50 - 50 share of net trip revenue between crew and vessel owner. The proportion of the lay received by each crew member is determined by the number of crew members and the share system agreed upon. As a rule, in the FT fleet, the captain receives 2 shares, the netman and engineer receive 1.5 shares each, and ordinary crew members receive 1 share each. Thus the lay is divided into 7 shares for a 5 man crew. In SPT and PKT vessels the lay is divided equally. The number of crew and shares are often given in the panggu records. In any event the Annual Boatlist lists the size of crews.

Most of the captains' and engineers' commissions were obtained from the panggu records. Where the former were omitted in the records, the average commissions paid by other vessels in the appropriate class were used. Omitted engineers' commissions were estimated from the mean minimum wage of the vessel class.

Food and trash fish commission were given in the panggu records but all other non-lay payments had to be established from other sources. The daily duit peti payments were reportedly quite uniform in the trawl industry of Kuala Kedah. Total duit peti was therefore obtained by multiplying estimated daily duit peti by the number of days between panggus when the trawlers did not go to sea.

Makan laut was estimated from records of the appropriate vessel class and proved to be the most difficult to estimate accurately. Since the crew members take the makan laut before the vessel owner receives the catch and often in a surreptitious manner, no records are kept of them. The crew are also characteristically coy about the weight and value of makan laut. To overcome these problems, the crew survey (Appendix A, QUES 1) of 1979 ensured that the crews of all operating FT, SPT and many of the PKT vessels in the panggu sample were interviewed as they prepared to leave the jetty after a trip. This enabled us to personally check the crews' estimates of their makan laut by weight and value. Their estimates of makan laut of previous years were scaled by the ratio of our estimates of 1979 and used to approximate payments of makan laut in past years. In the case of crews not comprehensively covered by the crew survey, their makan laut were set at the mean of their respective vessel-gear type in that year.

Trends in Crew Income : FT Fleet

The total average monthly real income of the FT crews has not, as illustrated in Table 7.6, declined in real terms over the 1969 - 1979 period. The real monthly income for ordinary crew, cooks (crew members paid extra crew payments), netmen and captains have remained essentially unchanged. Engineers' monthly real income increased, particularly after 1974, mainly as a result of a higher guaranteed wage precipitated by the general shortage and increased importance of engine-related skills following the introduction of the high opening trawl.

Monthly FT crew incomes were kept stable despite a very pronounced reduction in lay income, by the combined impact of a steady decline in crew size, absolute and relative increases in non-lay income and the shift to more powerful and profitable Class D and E vessels.

The average number of crew employed on FT vessels declined from 7.1 in 1969 to 5.4 in 1979 (Table 7.6). In the same period, however, the average number of shares decreased at a lower rate because the retrenchment was invariably of ordinary crews. The lay, duit laut and trash fish commissions were consequently shared amongst fewer persons. Moreover, a smaller crew meant a larger proportion of members could assume special functions and enjoy the accompanying higher income.

Non-lay income increased as a percentage of total ordinary crew income from 46% in 1969 to 67% in 1979. The relative expansion in non-lay income occurred primarily after 1975 as a result of additional duit laut and makan laut payments. The increase in duit laut payments was the effect of reduced crew size and the shift to more powerful vessel classes which consistently yielded successful catches. The sharp rise in makan laut payments to FT crews after 1976 in Table 7.6 was caused mainly by Class C and, in 1979, Class D crews. This rise coincides with the heavy losses of Classes C and D trawlers indicating, as will be seen in the next section, an attempt by their crews to compensate a low lay with makan laut.

Even though non-lay income, which uniformly accounted for at least 50% of total ordinary crew income, increased, the average monthly real income of an ordinary crew declined for each FT class in the 1969 - 1979 period (see Figure 7.2a-c). The decrease in crew size obviously did not offset the decrease in net trip revenue. However, the lay increased with engine size to the extent that the shift to more powerful Classes D and E vessels minimised the average decline in lay income for the FT fleet.

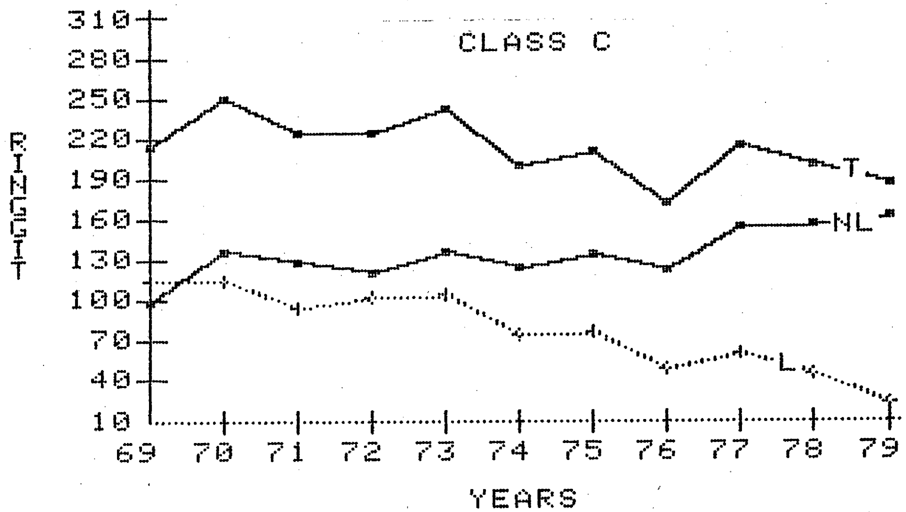
Trends in Crew Income : Prawn Fleets

Notwithstanding the short time period covered by the prawn trawler panggu records and the large fluctuations in lay, there is no distinct trend in average monthly real incomes of prawn trawl crews of SPT and PKT vessels (see Tables 7.7 and 7.8 respectively). The only exceptions are Classes A and B Pulau Ketam trawlers for which monthly crew income declined continuously in real terms after 1976. However, this decline in crew income is primarily the result of reduced days fished per month (see Table 5.10) rather than a decline in net trip revenue.

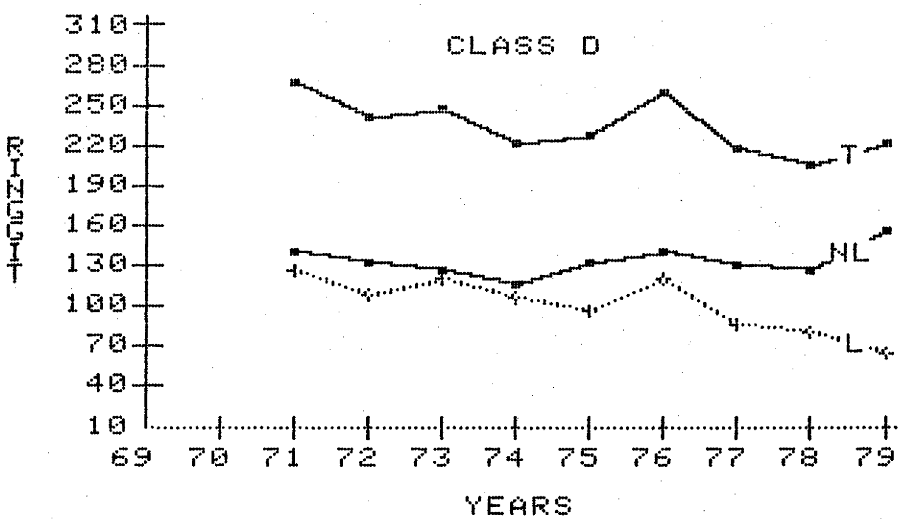
Non-lay income is less important and more stable in the case of prawn trawlers than it is for FT fleets. Prawn trawl crews do not receive duit laut. Trash fish commission per crew is lower because

FIGURE 7.2: MEAN MONTHLY EARNINGS PER ORDINARY CREW MEMBER IN THE FT FLEET: (a) CLASS C VESSELS, (b) CLASS D, AND (c) CLASS E VESSELS

Key:
- T - Total Earnings
- NL - Non-lay Earnings
- L - Lay Earnings



(a)



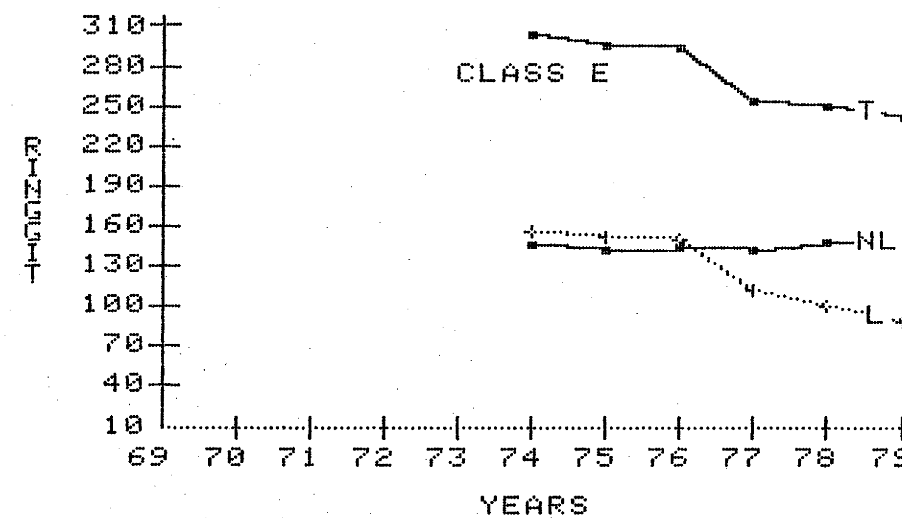


TABLE 7.7 : MONTHLY CREW EARNINGS : SPT FLEET (1969 RINGGIT)

	1972	1973	1974	1975	1976	1977	1978	1979
Class A								
Lay	239.95	117.47	76.10	117.76	177.05	159.59	120.14	124.72
Non-lay	96.03	92.88	94.93	92.34	96.76	92.81	83.23	79.02
Total	335.98	210.35	171.03	210.10	273.81	252.40	203.37	203.74
No. of crew	3	3	3	3	2.9	2.8	2.9	2.9
Class C								
Lay	n.a.	n.a.	n.a.	n.a.	256.85	166.62	183.64	227.30
Non-lay	n.a.	n.a.	n.a.	n.a.	108.05	93.95	86.92	88.42
Total	n.a.	n.a.	n.a.	n.a.	364.90	260.57	270.56	315.72
No. of crew	0	0	0	0	3	3.3	3.4	3.5

Source : Appendix E, Table 16
n.a. = not available

TABLE 7.8 : MONTHLY CREW EARNINGS : PKT FLEET (1969 RINGGIT)

	1975	1976	1977	1978	1979
All Classes					
Lay	228.38	272.48	198.41	167.32	160.82
Non-lay	69.28	78.30	72.91	69.41	67.19
Total	297.66	350.77	271.32	236.73	228.01
No. of crew	3.6	3.5	3.6	3.7	3.7
Class A					
Lay	256.54	263.92	206.04	166.21	116.58
Non-lay	61.97	69.93	64.13	62.18	61.90
Total	318.51	333.85	270.17	228.39	178.48
No. of crew	3	2.9	2.9	3	3
Class B					
Lay	223.60	255.03	193.70	169.16	184.28
Non-lay	77.31	84.58	81.94	69.16	65.93
Total	300.91	339.61	275.64	238.32	250.21
No. of crew	3	3.2	3.3	3.4	3.4
Class C					
Lay	176.30	286.51	209.30	169.14	155.81
Non-lay	67.69	82.66	74.70	73.63	67.36
Total	243.99	369.17	284	242.77	223.17
No. of crew	4	3.8	4	3.8	3.9
Class D					
Lay	n.a.	277.82	183.31	164.22	161.85
Non-lay	n.a.	73.74	70.59	71.67	68.94
Total	n.a.	351.56	253.90	235.89	230.79
No. of crew	n.a.	4.4	4.3	4.3	4.3
Class E					
Lay	n.a.	233.53	179.53	165.94	214.01
Non-lay	n.a.	96.42	73.46	65.22	76.08
Total	n.a.	329.95	252.99	231.16	290.09
No. of crew	n.a.	4	4.2	4.4	4

Source : Appendix E, Tables 17 - 20
n.a.= not available

the trash fish landed by prawn trawlers fetch lower prices. Makan laut is better controlled by the owner-operators and is generally less than what the FT crew receives. As will be seen shortly, prawn trawlers are also in general more solvent. The PKT crew also receive particularly low non-lay income as a result of the multi-day trips during which all trash fish, except for that landed on the last day of the trip, is dumped at sea and as a result of which there are fewer landings and fewer attendant daily non-lay payments.

It is interesting to note in Table 7.8 the absence of any distinct relationship between class or engine size and total monthly crew income in the PKT fleet. The SPT fleet (Table 7.7) and the FT fleet (Table 7.6) crew income on the other hand display a positive relationship with engine size or vessel class. The homogeneity of crew income in the PKT fleet stems from the parallel uniformity of net revenue already mentioned. The distinct decrease in average real monthly crew income in the PKT fleet (Table 7.8) is primarily the result of a shift to classes which exhibit a sharp decline in effort per month.

Trends in Crew Income : All Fleets

The FT fleet has, on the average over the 1975 - 1979 period and in particular after 1977, provided a greater average income to its labour force than have the two prawn fleets (Table 7.9). Despite a more buoyant lay in the prawn trawl fleet, the FT crews have received higher and more stable average incomes as a result of the non-lay payments and special function commissions. There is of course a wide distribution of income among the FT crews with the captain often receiving twice the income of the ordinary crew (Table 7.6). The

TABLE 7.9 : MEAN MONTHLY CREW INCOME FOR FT, SPT, PKT AND COMBINED FLEETS (1969 RINGGIT)

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
SPT Fleet	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	213.57	282.37	253.21	209.70	214.90
PKT Fleet	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	297.60	350.77	271.32	236.73	228.01
FT Fleet	237.34	312.31	290.60	289.28	310.67	273.26	294.06	314.84	310.65	298.55	298.88
ordinary crew	214.17	249.76	233.91	229.95	243.16	213.01	225.92	239.64	234.01	230.31	231.08
Trawl Fleet	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	270.30	310.19	283.27	253.09	246.10

Source: Tables 7.6, 7.7 and 7.8.

n.a.- not available

1. Due to incomplete information assume:
   1. In SPT Fleet that Class B = Class A and Class C in 1975 was equal to results of Class C in 1976
   2. In PKT Fleet that results during 1975 for Class D were equal to the Class D results of 1976
   3. In FT Fleet that in 1969 and 1970 Class D was equivalent to Class C and in 1972 and 1973 Class E was equivalent to Class D.

greater stability of FT crew incomes means that although the ordinary crew's income was on the average significantly below that of prawn trawl crews, it exceeded the latter in lean years such as 1978. SPT crews received the lowest average real monthly income which is exceeded by FT ordinary crew income in 3 out of the 5 years from 1975 and 1979.

Opportunity Wage

The crews' ability to get work in other fishing and non-fishing activities and their preferences determine the occupations to which they would move as an alternative to trawling. Opportunities and preferences would vary among individuals especially in the light of information available to each. In general, ability and preference are functions of jobs available, job 'status', wage rates and the skill, experience and motivation of the crew.

Kedah/Perlis's large number of unskilled youths between the ages of 15 - 24 with little education and work experience are apt to find opportunities in a non-agricultural job market, already sagging with unemployment and under-employment, few and far between. Yet the agricultural sector from whence these youths originate has increasingly exhibited seasonal and, at least in some regions, annual labour shortages. This apparent disequilibrium in the labour market is mainly a function of preference for urban jobs and lifestyles rather than of wage rate differentials [Lim, 1980]. Many youths prefer to be under-employed in the urban job market while waiting for more permanent and desirable employment than to accept full time work in the rural sector at the expense of losing their place in the 'queue'. Although the rapid growth of the Malaysian economy since

1969 has improved rural and urban job markets for unskilled youths, Kedah/Perlis has not been able, nor will they be able to in the near future, absorb its local supply of such labour except, perhaps, with the aid of inter-regional migration.

At the time of the crew survey in 1979, the trawler labour force was no longer dominated by unskilled youths as was found to be the case in earlier studies. The average trawler crew member was between 25 - 35 years old and married with 1 to 3 dependents (see Table 7.10). The average age of the Chinese members was higher than that of the Malays mainly because the former dominated the skilled crew positions.

Even though the trawler crew, irrespective of race or function, had on the average less than a primary level (6 years) of education and have reported their inability to procure skilled work outside the fishing sector, many of them have work experience in non-fishing sectors and are pecuniarily motivated. 57% of the trawl crew had had non-fishing jobs on a permanent basis. Malays, who are 62% of the trawl labour force, have had a higher incidence of non-fishing job experience largely because of their agricultural origins. The non-fishing work experiences of trawler crews were, however, mainly in low status agricultural jobs or casual labour.

Fishermen in under-developed or stagnant regions are often said to be occupationally immobile, a factor which contributes significantly to a high incidence of poverty among them. Our crew survey showed conclusively that the trawler crews would leave the industry for other equally remunerative employment. The initial value-oriented questionnaire of the survey (Appendix A, QUES 09), designed to rank the monetary, social, intrinsic and expressive

TABLE 7.10 : BIBLIOGRAPHICAL DATA ON TRAWL LABOUR FORCE IN KUALA KEDAH

		Crew : Race Composition			Crew : Skilled and Unskilled			
		All Races	Malay	Chinese	All Skilled	Unskilled All	Unskilled Malay	Unskilled Chinese
Race								
Malay	%	62	-	-	32	78	-	-
Chinese	"	36	-	-	65	20	-	-
Others	"	2	-	-	3	2	-	-
Age	years	30.4	27.2	35.5	35.1	28.1	26.1	34.3
(s.d.)		(10.1)	(8.2)	(11.6)	(13.9)	(8.9)	(7.6)	(11.4)
Education	years	5.0	5.3	4.4	4.7	5.1	5.4	4.2
(s.d.)		(2.6)	(2.4)	(2.8)	(2.1)	(2.6)	(2.5)	(2.6)
Married	%	42	49	30	18	55	57	45
Dependents	No.	2.6	2.2	3.2	2.7	2.0	1.8	2.7
(s.d.)		(1.7)	(1.7)	(1.8)	(2.5)	(1.4)	(1.5)	(1.2)
Presently with work outside fishing sector	%	2	3	0	3	2	3	0
Have worked outside fishing sector	%	57	64	43	44	64	69	42
in a) farming	"	39	53	12	18	49	57	19
b) casual labour	"	26	26	25	6	14	14	13
c) factories	"	11	13	7	8	13	14	6
d) government	"	1	1	1	0	1	1	2
e) construction	"	8	8	9	5	10	8	13
f) motor shop	"	3	1	9	6	2	1	6
g) forestry	"	2	2	1	4	1	1	0
h) others	"	15	13	18	14	16	14	19
Can obtain skilled work outside fishing sector	"	8	3	15	13	5	3	10
No. of observ.		230	143	83	78	152	118	31

Source : Crew Survey

values of the trawl fishermen, disclosed that they all entered and remained in the industry because it offered them the highest possible income in the circumstances. All other values were unquestionably subservient at best. Only 2 of the 234 crew interviewed expressed a desire to have their children work in the trawl fleet. This reflects the low status of trawl fishing: trawl crews spend 15 hours a day often seven days a week working in hazardous conditions (especially as most of them cannot swim) and some unemployed youths would not even consider accepting such work for any feasible wage. It would seem that the age, responsibilities, work experience and motivation of the trawler crews argue well for their ability and willingness to pursue better paying jobs in other sectors.

Opportunity Wage Rate Compared With Mean Monthly Income

Information on many occupational types, especially in the informal sector, in Malaysia is scarce and incomplete. In Table 7.11, the real monthly income of FT crews is juxtaposed with the real monthly wage rates of several occupational types into which trawl crews may enter in lieu of trawling. FT crew real monthly incomes exceed that of all the comparable alternative occupations, which receive less than 65% of FT crew real monthly income.

Admittedly, some of the wage statistics in Table 7.11 may not have been as thoroughly compiled as those of the FT crew. For example, rubber estate workers (50% of all estates in 1977) often receive subsidised housing and enjoy other amenities. In any event the disparity in wage rates is too great (about 50%) to deny the fact of superior real FT income.

TABLE 7.11 : MONTHLY WAGES FOR OCCUPATAIONS COMPARABLE TO FT FLEET IN 197

	Real Wages	Days Wrk./Mth.	Fishing Industry Real Wages	
Rubber Estates				
foremen	$154	26	$400.18	captains
tappers (male)	$134	23	$231.08	av. crew
weeders (male)	$93	22	$231.08	"
Rubber Factories				
artisans	$150	25	$269.50	netmen
others (male)	$122	24	$231.08	av. crew
Bus Companies				
drivers	$193	26	$398.47	engineer
bus conductor (male)	$173	25	$231.08	av.crew
workshop				
a) skilled workers	$219	27	$400.18	captains
b) semi-skilled wkrs.	$172	26	$269.50	netmen
clerks	$206	25	$231.08	av.crew
labourers	$118	27	$231.08	"
apprentices	$99	25	$231.08	"

Source: Monthly Statistical Bulletin, 1979.

A central question that remains is whether the higher trawl income is a result of supra-normal rents passed to the crews or is simply the reservation wage needed to lure men into the industry. Although no conclusive answer is possible, available evidence indicates that the latter is the case. Given the large pool of unskilled labour in the region, it would seem reasonable to expect a queue of potential entrants if the income of trawl crews was greater than the prevailing reservation wage. On the contrary, many vessel owners had difficulty in obtaining crew and there was no queue in 1979. Indeed unemployed youths interviewed on the field were reluctant to accept the physical and social 'hardships' of such employment and risk their disenfranchisement from their ultimate goal, the urban job market.

In the prawn fleets, any resource rent received by the vessel owners would be passed to the crew. However, the mechanism for determining crew wages in the FT fleet denies them information to trends in trawler profitability and allows wage rates to be set at or near the reservation wage. As seen in previous discussion, FT vessel owners control the size of the lay via ex-vessel prices and FT crew are able to set a minimum income level via non-lay payments which will probably be equivalent to the going reservation wage. If this is so, however, the question of why the FT crews have a higher supply price than either the SPT or PKT crews remains. As was seen earlier, the average monthly income of the FT crews was higher and more stable than that of either prawn fleets. The primary explanation of this discrepancy lies in the large number of skilled employees in the FT fleet. Prawn trawl vessels are characteristically owner operated with the owner undertaking most if not all skilled jobs (i.e.as the captain, netman and engineer). The owner therefore does not make extra payments for skilled services. Prawn trawlers are also generally small vessels.

To sum up the above, the trawler crews receive relatively high wages primarily because of the arduous and non-preferential nature of the work. The members of the trawler labour force, though unskilled, are willing and able to take up comparable employment in other sectors for higher wages. They are not occupationally immobile like many unskilled youths or fishermen elsewhere. It follows that the FT crews' shadow wage rates or the social value of labour can be considered to be equivalent to prevailing income rates.

d) Rates of Return to Vessel Owners

i) Vessel Operations

Net Vessel Income and Costs

All trawl vessel owners in Kedah/Perlis receive 50% of the net trip revenue. FT vessel owners also receive duit laut payments equal to half that received by the combined crew. From their share of the net trip revenue the trawl owners must meet some crew payments, repair and maintenance (R.& M.) costs and the user cost of capital.

All FT vessel owners must cover the commissons given to the captains and engineers as well as duit peti payments. In the case of prawn trawl fleets, only duit peti is incurred as there are no special function commissions.

Documentation costs prevented FT vessel owners from keeping repair and maintenance records which, unlike the trip receipt and panggu records, are not needed for the payment of crews or vessel owners. The prawn trawl market agents in their monopsonistic positions and in pursuance of their book-keeping functions kept and provided complete annual R. & M. records of each trawler in the panggu sample.

The annual average R. & M. cost for the FT vessel was approximated by using itemised recall estimate of R. & M. cost in 1978 and the CPI for machinery and transport equipment. In the capital survey (QUES 05), each vessel owner interviewed was asked to estimate the value of R. & M. cost per vessel expended in 1978 for the hull, engine/gear box and net or other equipment. The estimates of R. & M. thus obtained were clarified with other market agents if their truth was in doubt and either a satisfactory estimate was obtained or the respondent was excluded in subsequent analysis of R. & M. costs. The mean itemised R. & M. cost for each FT class for 1978 was then multiplied by the CPI (1978 base) for machinery and transport equipment in order to estimate the average itemised R. & M. per FT class in the remaining 10 years from 1969 - 1979.

An integral aspect of the annual cost borne by the vessel owner is the decline in the economic value of the current and future services derivable from the capital stock, hereafter referred to as the user cost of capital. The user cost of capital is most comprehensively measured by changes in market value which take into consideration the physical depreciation of the capital item, the expected future earnings and the penalty arising from the availability of better items. These three considerations will, consistently with Yotopoulos (1967) be called depreciation, exhaustion and obsolescences, respectively.

A highly developed market exists for all major capital items used in the trawl fishery. Most hulls, engines and gearboxes are in fact purchased as used or reconditioned items. As these engines and gearboxes suffer a high rate of depreciation and obsolescence (e.g. a 175 h.p. engine has an average lifespan of 4.9 years), the market agents have to keep in constant touch with the second hand market for capital items. Consequently it was possible to obtain complete purchase and disposal information on each major capital item from which the average annual user costs of capital can be established. In the capital survey, information on prices and dates of sales and purchases were collected for each major capital item used on the vessel ever since it was owned by the interviewee. The capital stock unsold at the time of the survey was valued at the expected market value. From all this information the annual hull, engine and gearbox user costs for each vessel were assumed to be the average annual change in market value in the life of the item.

Nets had to be treated differently from the other capital items because of their short lifespan. Prawn nets last an average of 1.2 years while high opening nets, on the average, last less than 9 months. Consequently there is no second-hand market for them and few vessel owners remember net purchases. The average decrease in value of total stock of trawl nets for each vessel-gear type was estimated from information from the capital survey on the number, value and average lifespan of each trawl type. The 1978 user cost of nets per vessel-gear type in 1978 was then multiplied by the CPI (base year 1978) for machinery and transport equipment to estimate the user cost of nets in the rest of the 1969 - 1979 period.

Value of Capital Investment

The average annual value of capital invested in each vessel gear type was calculated with the information from the capital survey.

Assuming a constant rate of change in market value over the life of an asset, the investment value of each major capital item per annum was calculated with a declining balance of market value. The annual capital value was thus equal to the purchase price minus the sum of user cost incurred in all previous years. Trawl nets were not treated as capital investments because of their short life expectancy.

Although trawl (gear) licences are legally non-transferable, they are often sold, alone or with a vessel for much more than their face value of $35.00 per annum. As stated in Chapter 4, the purchase price of a trawl licence under a scheme of limited licences should, if the licence is transferable and issued differentially by the prime determinants of vessel productivity, approximate the certainty equivalent of expected future resource rent to be earned from its use. With certainty and risk aversion, however, certainty equivalent of the licence is less than the expected value of rent. In these circumstances, the purchase value of the licence would provide an accurate and low cost means of assessing the bionomic state of the fishery. But in Kedah/Perlis, the illicit nature of licence transfers together with the fact that licences are not allocated on the basis of vessel-gear type makes licence values an inaccurate gauge of the efficiency of resource allocation in the trawl fishery. These same practices also create conditions which make it difficult to obtain a schedule of licence values in particular for the past years. Nonetheless the fact that trawl licences have large resale value net of fees for renewal, indicates that the combined trawl fleet does and is expected to continue to earn rents in excess of the opportunity cost of capital.

Since many of the vessels in the capital survey were issued licences by the Fisheries Division or operated without a licence at all, the investment of the trawl licence could not be estimated in the same manner as the other major capital items. As an alternative, an estimate of the expected sale value of their licences was solicited from the respondents of the capital survey. From these and a few records of licence sales in previous years, a schedule of licence values categorised by tonnage class was drawn up in Table 7.12. Trawl licences stipulate the tonnage of the vessel to which it is issued and can therefore only be used by other trawlers of a similar tonnage. On the advice of a cooperative market agent, the vessel ranges were set at 0 - 14.9 tonnes, 15 - 24.9 tonnes, and 25 - 50 tonnes.

The value of trawl licences from Table 7.12 was quite high and had increased in real terms over time. The high value in 1979 shows clearly that trawl licences constitute a quasi property right to a valuable resource and imply the existence of resource rent. Little else can be said of the trend of increasing licence value given the small number of observations on which it is based.

Since the purpose of calculating the rate of return is to ascertain the existence of supra-normal profit due to resource rent, licence values should not be included in capital investment. Although many of the trawl owners have had to purchase a licence at a substantial price, this price embraces in part the expected supra-normal rent and therefore should not be included in the rate of return calculation.

Prawn trawler owners depend on their market agents for cash flow and loans, the charge for which is included in the mark-up imposed by the market agent. Gross trip revenue listed on panggu records is thus net of charges for rolling capital and other services rendered.

TABLE 7.12 : SCHEDULE OF TRAWLER LICENCE VALUES BY TONNAGE CLASS [1] (1969 RINGGIT)

Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Tonnage Class											
0 - 14.9							483.09	538.36	513.91	544.47	531.60
							(2)*				(51)**
15 - 24.9							690.13	807.54	899.17	967.94	1063.20
							(3)*				(25)**
25 - 50	1000	981.36	1062.80	1100.19	1058.43	1082.25	1207.73	1345.90	1445.09	1512.40	1624.34
			(2)*		(1)*						(56)**

Source : * Panggu records

** Capital survey

[1] Assume a constant rate of change between available records

Number of observations in parenthesis

Owners of prawn trawl vessels do at times supplement funds from their market agents from loans from other sources. However, FT vessel owners are rarely tied to a market agent and must meet their own demands for funds.

The panggu records for prawn trawlers list all financial transactions between the market agents and his clients' vessels, including any funds, whether the clients' own or borrowed, trusted to the agents. The average annual amounts of outside funds paid into prawn trawl accounts by prawn trawl vessel-gear classes are given in Appendix E, Tables 24 - 27. They vary considerably over time and amongst vessels. The vessel owners only contribute funds in relative amounts for major capital purchases and in most years a prawn trawl owner would not invest his own or borrowed funds.

The average annual itemised net vessel income, R. & M., user cost and capital investment of each trawl class in the panggu sample are given in Appendix E (Tables 21 - 23 for the FT fleet, Table 24 for the SPT classes and Tables 25 - 27 for the PKT fleet). Annual income for all fleets was calculated with panggu records while all costs and investments were derived from information collected in the capital survey. The only exception is the R. & M. of prawn trawlers which is in the panggu records.

ii) Marketing Operations

FT owners who usually act as market agents as well receive net vessel income and income from their marketing activities. Marketing income is composed of the gross revenue from sale of catch minus that share which is given to the vessel in the form of gross trip revenue.

With the marketing income, the FT firm must meet the variable costs of handling, transport, and labour and fixed costs.

Average annual net marketing revenue per FT vessel class was estimated as the product of average per annum gross trip revenue net of local transport costs, and duit laut payments and the corresponding market margin for pooled species given in Table 7.1. Trash fish sales were included in the annual gross trip revenue under the assumption that they received the same marketing margin as pooled species. Since CIF price was used to derive the marketing margins, it was not necessary to consider further variable cost.

FT firms are usually family businesses and only the larger firms employ non-family labour. Just as in similar set-ups in other businesses in Malaysia, wages paid to members of the family for services rendered often bear no relationship to their value or opportunity costs. Family labour used in the marketing activities of the firm were thus ascribed published wage rates for comparable occupations. The two general categories of labour used by the FT firms were clerical and manual labour. Consequently the monthly wage rates for these occupations given in the Monthly Statistical Bulletin (1967/1979) were imputed to the average annual marketing labour cost for an FT vessel on the assumption that each vessel required one man year of clerical and one man year of manual labour.

Since there is no separation of ownership from management in the FT fleet or in comparable family entreprises in Malaysia, management costs were not included in calculating either the FT net vessel income or the FT net marketing income. Moreover, the FT firms are small family businesses which have entered into trawling with knowledge and managerial skills gained through association with the large scale fishing sector. As such their managerial skills and knowledge are an integral part of their total capital investment and cannot be accurately distinguished from the latter. Opportunity costs of human capital is also quite low because the managerial skills and goodwill earned in the trawl fishery are seldom fully transferable to other occupations.

Fixed costs incurred in the average FT firm's marketing activities were estimated from information collected in the market agent survey (QUES 10) and consumer price indices for machinery and transport equipment (base year 1979). In the market agent survey, estimates of the average monthly cost in 1979 of each major fixed expenditure including rent, telephone, transportation, and equipment, were made. The average monthly total fixed cost of an FT firm was $320 and the annual total fixed cost per vessel in 1979 was $1280 (because the average FT firm has 3 trawlers).

Rolling Capital

FT firms must have sufficient liquid funds to cover marketing, crew and R. & M. expenses because they often do not receive payment from a consignee for up to two weeks. The rolling capital stock required to meet these expenses was estimated by rule of thumb : it was assumed that rolling capital equivalent to two months' gross trip revenue and 1/6th of the total annual R. & M. costs were needed to meet marketing and crew expenditure and R. & M. costs, respectively.

Marketing revenue, costs and rolling capital are summarised by FT class in Appendix E, Tables 28 to 30 which also include the average vessel income and investment, and estimates of annual rate of return on total investment.

iii) Opportunity Cost of Capital: Vessel and Marketing Operations

Like most capture fisheries, trawling in Kedah/Perlis is a very risky investment. Catch rates fluctuate, equipment fail or become obsolete prematurely, crew leave and pirates strike. The expected rate of return in trawling must therefore exceed that of less risky and more certain investments like fixed term deposits, stocks and bonds. More importantly, the returns from these formal market transactions do not fairly reflect the opportunity cost of trawling investment. It is submitted that a more feasible (and therefore better measure of the opportunity cost of trawling investment) investment alternative is the informal money market in which vessel owners and market agents conduct most of their money transactions.

Formal and informal market transactions of the vessel owners were examined in both the market agent and capital surveys. Only 25% of the vessel owners and market agents interviewed in the surveys have taken any major loans in the informal market although most of them regularly accept short term credit from input suppliers. Only 4% of those who took major loans did so from the formal market (i.e. banks, cooperatives, government and associated sources); the other 96% borrowed from moneylenders or through money syndicates [2].

The average annual interest rate of loans in the informal money

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[2] The main source of credit and investment used by the trawl owners in Kedah/Perlis is a fund called the 'kutu'. This involves a syndicate of usually 5 to 10 persons who contribute an equal share of money towards a central fund. Contributors bid for the use of this fund which is loaned to the bidder who offers the highest rate of repayment for a fixed period of usually 6 months. These syndicates may be ad hoc or may repeat their functions as the members desire.

market in 1978 was 18.8% compared to the prime interest rate in the formal money market of 7.5%. The opportunity cost of capital in the trawl industry is thus assumed to be 18.8% which in real terms is about 11%. This figure will be used both in the simulation model in the next chapter and for purposes of comparison in the next section.

7.3 Rate of Return to Total Operations

The average annual real rates of return (with labour priced at opportunity cost or shadow wage rate) of the FT, SPT and PKT fleets in Tables 7.13, 7.14, and 7.15 respectively, show clearly that supra normal profits have been the norm in the trawl industry. The high average rates of return in 1978 - 1979 demonstrate that even after 15 years of trawling, the average or marginal trawler was earning substantial resource rent. Furthermore, there is no decrease in the average annual real rate of return over the period covered by the panggu records which suggests that the potential resource rent has not been completely dissipated via inflow of vessels. The average annual real rate of return for the combined trawl fleet in 1978 - 1979 was 39%, greater than three times the estimated opportunity cost of capital (of 11%).

All trawler vessel-gear types, except Class C fish trawlers, earned a rate of profit greatly in excess of opportunity costs of investment. The annual real rate of return of SPT vessel classes and Class E fish trawlers were particularly high averaging (weighted average) 46% and 40% respectively during 1978 and 1979. Neither the SPT fleet nor the FT fleet suffered a decline in average annual real rate of return. On the contrary, the average profitability of the FT fleet increased noticeably after 1974 with the shift to Class E

TABLE 7.13 MEAN ANNUAL RATE OF RETURN OF FT FLEET (1969 RINGGIT)

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
All Classes											
1. Net Mkt.Inc.[1]	3754.91	2133.61	3485.61	3131.96	4594.10	4019.97	11240.73	11301.52	10217.12	11629.42	7236.06
2. Net Ves.Inc.[2]	3604.05	2064.26	1889.69	697.66	1296.32	(396.05)	(1352.50)	(263.18)	(2566.49)	(3020.54)	(3873.84)
3. Total Net Inc.	7358.96	4197.87	5375.30	3829.62	5890.42	3623.87	9888.23	11038.34	7650.63	8608.88	3362.22
4. Total Invest.	19183.55	19147.54	18136.71	19485.31	18748.83	17463.34	17945.65	20316.58	20177.80	19904.73	18531.04
5. Rate of Return	39%	22%	30%	20%	32%	21%	56%	54%	38%	44%	19%
Class C											
1. Net Mkt. Inc.	3754.91	2133.61	2876.38	2719.62	3932.96	2811.39	8207.74	5160.07	4306.02	4781.48	1125.49
2. Net Ves. Inc.	3604.05	2064.26	1434.58	990.84	1526.58	(981.70)	(1981.90)	(2890.18)	(4304.51)	(5618.65)	(6804.65)
3. Total Net Inc.	7358.96	4197.87	4310.96	3710.46	5459.54	1829.69	6225.84	2269.89	1.51	(837.17)	(5679.16)
4. Total Invest.	19183.55	19147.54	16528.98	17517.99	16358.46	15050.91	14661.44	13541.82	12568.78	11748.25	8807.89
5. Rate of Return	38%	22%	26%	21%	33%	12%	42%	17%	0%	(7)%	(64)%
Class D											
1. Net Mkt. Inc.			5263.56	3831.67	5534.94	5338.90	13081.77	12784.83	9240.06	9641.89	4983.75
2. Net Ves. Inc.			3257.02	200.12	968.63	(56.81)	(1886.74)	293.83	(3253.52)	(4201.46)	(5234.39)
3. Total Net Inc.			8520.58	4031.79	6503.57	5282.09	11195.03	13078.66	5986.54	5440.43	(250.64)
4. Total Invest.			22828.64	22823.79	22150.51	19780.31	19404.28	21040.02	18055.19	16736.35	14492.70
5. Rate of Return			37%	18%	29%	27%	58%	62%	33%	32%	(2)%
Class E											
1. Net Mkt. Inc.						8603.74	19978.41	16607.11	13635.32	14384.79	8928.29
2. Net Ves. Inc.						3874.53	3528.33	2133.33	(1288.35)	(1791.32)	(2983.85)
3. Total Net Inc.						12478.27	23506.74	18740.44	12346.97	12593.47	5944.44
4. Total Invest.						28770.39	29197.81	27666.33	25168.73	23531.59	21350.75
5. Rate of Return						44%	81%	68%	49%	54%	28%

Source : Tables 28-30, Appendix E

[1] Vessel owners are assumed to maintain the same marketing mark-up during 1969 - 1972 as they did in 1973.

[2] The net income of Class D vessels in 1969 and 1970 are assumed to be equivalent to that of Class C vessels in those years. The net income of Class E vessels in 1972 and 1973 are assumed to be equivalent to that of Class D vessels in the same years.

Note : Negative values are enclosed in parenthesis.

TABLE 7.14 MEAN ANNUAL RATE OF RETURN OF SPT VESSELS (1969 RINGGIT)

	Class A					Class C			
	1975	1976	1977	1978	1979	1976	1977	1978	1979
1. Net Vess. Inc.	1192.24	2982.58	2364.38	1823.54	1791.32	3284.14	1755.98	2414.48	5126.87
2. Total Invest.	4857.65	4840.65	4136.64	3990.42	4298.49	7857.80	6759.98	5902.05	5803.03
3. Rate of Return	25%	62%	57%	46%	42%	42%	26%	41%	88%

Source: Table 24, Appendix E

TABLE 7.15 MEAN ANNUAL RATE OF RETURN OF PKT VESSELS (1969 RINGGIT)

	Class A					Class B				
	1975	1976	1977	1978	1979	1975	1976	1977	1978	1979
1. Net Vess. Inc.	4310.61	5307.38	3309.94	1842.92	660.12	1943.00	4275.55	2270.03	1865.73	1799.31
2. Total Invest.	5066.78	5348.51	4957.56	4249.64	6379.42	9064.42	7850.55	6345.65	7861.47	5989.12
3. Rate of Return	85%	99%	67%	43%	10%	21%	54%	36%	24%	30%
	Class C					Class D				
1. Net Vess. Inc.	2499.16	7306.26	3961.76	1550.22	1516.15	n.a.	8817.37	3142.83	3011.66	2151.38
2. Total Invest.	8821.27	10031.53	9471.05	9923.24	9352.05	n.a.	11872.98	11139.79	9658.79	9698.31
3. Rate of Return	28%	73%	42%	16%	16%	n.a.	74%	28%	31%	22%
	Class E					All Classes				
1. Net Vess. Inc.	n.a.	5010.78	2111.23	2576.53	3929.76	n.a.	6349.42	3201.01	2005.56	1691.67
2. Total Invest.	n.a.	18690.50	17709.58	17861.73	15322.10	n.a.	8787.07	8283.35	8659.57	8532.00
3. Rate of Return	n.a.	27%	12%	14%	26%	n.a.	72%	39%	23%	20%

Source: Tables 25-27, Appendix E

vessels. Only the PKT fleet experienced a continuous deterioration in profitability after 1976. This phenomenon, like the simular trend in PKT crew income, is due mainly to a reduction of rate of effort and the exceptionally good harvest in 1976 rather than to a distinct decline in net trip revenue.

Vessel owners apportion total value added amongst the crew and themselves via the administration of ex-vessel prices (Table 7.13). The sharp increase in marketing margins after 1975, which coincided with an improvement in the average profitability of the fleet, produced a 2 - 3 fold increase in net market income but yielded a continuous decline in net vessel income. After 1974, the harvesting or vessel operations of the average FT fleet became increasingly more insolvent. Even the highly profitable Class E trawlers recorded a deficit in net vessel income after 1976. The greater share of total value added accruing to the market operations after 1974, is undoubtedly an exemplification of limits placed on trawler income.

The unbalanced allocation of total revenue between the vessel and marketing activities underlines the need to take into account the integrated nature of FT firms. In previous studies of the FT fleet, only net vessel income and capital investment were included in calculating vessel profitability. This practice grossly underestimated the true profitability of the FT fleet and prevented a proper diagnosis of the fleet's bionomic condition.

The profit rate differentials amongst the FT classes, illustrated in Table 7.13, accounts for the rapid shift to more powerful vessel classes after 1973. With the complete adoption of the high opening net in 1973, vessel profitability increased directly with engine horsepower. While the more powerful vessels yielded a higher absolute profit rate, the less powerful vessel classes increasingly suffered losses. The marked decline in relative and absolute profitability of Class C trawlers illustrates the penalty, discussed in Chapter 4, for not adopting technological innovations. As new and more powerful vessels enter the fishery, the biomass is decreased thus reducing the catch rate and earnings of existing and less powerful vessels. The latter (such as the Class C FT vessel under study) will sustain losses unless they adopt new technology in the form of larger engines.

7.4 Prelude to Chapter 8 : A Summary of Economic Parameters for the Norsim II Simulation Model

The rapid increase in fishing intensity resulting from the shift to Class E vessels and the rapid and marked decline of Class C FT vessels' solvency suggest that the fleet has not reached a steady-state condition. If this is found in the next chapter to be valid, then the supra normal profits earned by the FT fleet are not sustainable and the FT fleet may well have expanded beyond even its open access equilibrium state.

As a prelude to Chapter 8, the following summarises the economic parameters that will be used in Norsim II.

Prices

An infinitely elastic demand function will be assumed for all taxa in the simulation model although this may be unrealistic for some of the low grade taxa such as Scianidae and Carangidae. As most of the FT catch is consigned throughout Malaysia and Singapore, it represents a very small proportion of the total fish consumed in the combined market and should not have a significant effect on fish prices.

In view of the shift in market margins in 1975, and the instability of, particularly, market prices, the average real ex-vessel and market prices over the 1975 - 1979 period will be used as the base case prices for each taxon in the simulation model.

Transport Deductions and Trip Costs

In the simulation program, constant per diem trip cost will be assumed for each vessel class. In subsequent simulation runs, autonomous shifts in trip costs will be introduced to examine the effect of changes in diesel costs. Even though this assumption essentially discards the theory of the firm and reverts to the rigid constant cost of fishing effort assumed in the static model, the absence of conjoint catch and costs records do not leave an alternative. As pointed out by Huppert [1975,pp.104-105] the assumption of fixed cost of effort not only presumes that costs are insensitive to prices or biomass density but also that the rate of effort per day is constant throughout the simulated period. Increase in the effort per day is, however, unlikely since there has been no major change in rate of effort per unit of effort since the early 1970s and in view of the fact that the vessels already operate 15 hours per day.

The trip costs in 1969 Ringgit averaged over the 1976 - 1979 period will be used as the base case in the simulation model since the trip costs for each FT class were notably stable after 1976 following the last diesel price increase. Likewise, the average transport deductions in the 1976 - 1979 period will be used to estimate the pre-panggu deductions.

Labour Costs

The treatment of labour costs in the simulation model is not as straightforward. Since the purpose of the exercise is to estimate the potential value of the FT fleet regardless of its distribution between capital and labour, labour cost should be set at the aggregate shadow wage rate of the crew. Potential rent will thus be easily identified and accrue to the vessel owners. As discussed earlier in this chapter, the shadow wage rate of FT crews in Kedah/Perlis was found to be equivalent to their supply price or reservation wage. It was further established that the FT crews probably have not received any portion of the resource rent earned by the vessel owners but have only received their supply price. Thus the evaluation of alternative fleet sizes will be based upon the crew receiving a wage equivalent to that earned over the 1975 - 1979 period. When the optimum is established, the division of profits between labour and capital will be calculated assuming that the current share arrangement prevails.

Crew Income

In this case, the lay and special function commissions will be calculated using the same formula as operative in the FT fleet during 1978/79. The lay will be 50% of net trip income for 5 crew members and 7 shares. The captain's commission will be assumed to be 12.5% of the vessel owner's share while the engineer's commission will be calculated on a guaranteed wage of $350 per month. The non-lay income is more difficult to forecast. Since there was a distinct shift in market margins (which determine to a large extent non-lay payments) and technology in 1975, the average over the 1975 - 1979 period will be used as the base case for each non-lay payment source.

Annual Vessel Costs

Vessel costs which include repair and maintenance (r. & m.) and user cost of capital will be treated as a constant per diem cost in the simulation program. These vessel costs could reasonably be expected to vary with the number of days at sea per year. Since the rate of effort per annum will be assumed constant in the simulation program, the vessel costs will be treated as annual fixed charges. Annual vessel costs were relatively stable over the 1975/79 period, displaying no distinct trend. The annual vessel costs for each class of vessels will therefore be set equal to its average annual vessel cost over the 1975 - 1979 period.

Similarly, annual marketing costs which are inclusive of labour costs and infrastructural costs will be treated as annual fixed charges. Since both categories of marketing costs are based, to a large extent, on surveys carried out in 1979, the annual market costs will be set at these 1979 levels in the simulation model.

As a result of rapid technological change represented by a shift to more powerful vessel classes and the short expected life of all major capital items (except the hull) capital consumption has accrued at a much greater rate through capital replacement for each FT vessel class. The average annual capital value of each vessel class has thus declined steadily through the period studied. This declining trend in capital values will probably continue as new vessel classes are introduced and adopted. However, in the simulation model the existing range of technology is assumed to be constant throughout the simulated period. If this situation was to eventuate, capital values, especially in Class E, would increase as vessel owners are forced to replace equipment. The annual capital value averaged over the expected life of a new vessel in a given class would thus be the appropriate cost parameter. As an approximation of this value, the annual capital value averaged over the period for which estimates are available will be employed for each vessel class incorprated in the simulation run.

Calculating a value for marketing investment poses problems similar to the derivation of capital value. Rolling funds, as estimated earlier, were defined as a function of gross revenue and costs. Therefore as revenue and cost increase with, for instance a reduction in fleet size, rolling funds would accordingly be expected to increase, though probably at a decreasing rate. As for all other cost components, the calculation of potential rent will be carried out assuming a constant value of invested funds. This somewhat simplistic assumption is made in lieu of a more rigorous estimate of the cost functions. In line with this constant cost assumption, rolling fund will be set at the mean over the 1975 - 1979 period.

CHAPTER 8

ESTIMATION OF SUSTAINABLE RENT AND POLICY RECOMMENDATIONS

8.1 Introduction

In Chapter 7, it was found that the FT (Fish Trawl) fleet earned in the aggregate supra normal profits throughout the 1969 - 1979 period. Given the rapid growth in fishing effort, however, the sustainability of these returns is uncertain. This chapter attempts to resolve this uncertainty by calculating the potential rent of the FT fleet under steady-state conditions with the NORSIM II program. The primary focus here is the calculation of the open access and the fixed fleet that yields the maximum discounted value of the FT fishery over an infinite time horizon. Two alternative assumptions about the level of prawn trawl effort, two alternative sets of population models and three social discount rates were used in these calculations. The sensitivity of these results to changes in the economic parameters is examined by allowing fish prices and diesel costs to increase in turn at three alternative rates over the simulated period. To conclude this study, means of improving the existing licensing scheme in Kedah/Perlis will be discussed at the end of the chapter.

8.2 Assumptions

8.2.1 FT Fleet

The FT fleet, as shown in Chapter 5, has clearly shown a trend for the smaller h.p. classes to decline in importance and for the Class E vessels to become dominant. This trend, as shown in Chapter 7, was the consequence of the high absolute and relative profitability of

Class E vessels. If this trend continues unabated, Class C fish trawlers will exit the fishery as early as 1981 and Class D vessels will exit by 1982. Judging from the losses suffered by the Class C and D vessels in recent years, a complete conversion to Class E vessels is likely unless a larger and more profitable engine unit is introduced.

The calculated potential yield will therefore be made under the assumption that the FT fleet is composed of Class E vessels only. As no alternative technological development is imminent to transform the industry, no attempt will be made to introduce future changes in technology or vessel class into the calculation.

In Chapter 5, it was seen that the FT vessels are multi-gear units, in that they use both fish and prawn trawls. However, the importance of the prawn trawl has decreased substantially since the introduction of the high opening net. Class E FT vessels employ the prawn trawl on the average of 1.51 days per month or approximately 7% of total monthly effort. Obviously the prawn net is only used in periods where the expected net revenue (including market revenue) is greater than that expected from the fish trawl. Since the surplus yield models are based upon annual catch and effort rates, the simulation model will be unable to determine endogenously the amount of prawn trawl effort of the FT fleet. Another complication from incorporating the prawn trawl effort into the calculation of economic yield is the poor results of the surplus production model for the prawn taxon. Since over 60% of total revenue obtained from the prawn trawl is from prawns, an accurate estimate of the sustainable yield from this taxon is necessary for a calculation of the economic potential of the prawn fleets. However, the surplus production models, as seen in Chapter 6, did not provide a valid description of the prawn stocks. The economic yield of the prawn trawl fleets cannot therefore be calculated with any degree of confidence.

In view of the above, only the potential economic yield from high opening net activity will be examined. However, prawn trawl effort from all fleets will be included in the calculation of total CPUSE (catch per unit of standardised effort), for prawn trawlers do compete with the fish trawls for many of the taxa. The prawn trawl activities of the FT fleet will be treated essentially as a separate fleet with the annual vessel costs and investments of the FT fleet assumed to be borne by the high open trawl activities.

8.2.2 Prawn Trawl Fleets

The potential yield calculations were made under two alternative assumptions concerning the size and growth rate of the prawn trawl fleets. Under both, the distribution of the fleets' vessel classes will be assumed to be constant at their 1979 levels. This assumption is warranted by the stability of the vessel class composition of the SPT and PKT fleets over the 1975/79 period. The first alternative assumption concerning the level of prawn trawl effort (P_1) is that the prawn trawl fleets will remain at their 1979 size. The second alternative (P_2) assumes that each fleet grows at 5% per annum for the first 15 simulated years. P_2 represents approximately the average growth rate displayed by the SPT and PKT over the 1965/79 period. Under P_2 the SPT and PKT will increase from 618 and 131, respectively, in the first simulated year to 1285 and 272, respectively, in the fifteenth simulated year. The fleet will be assumed to remain at this level in later simulated years.

8.2.3 Surplus Production Function

It was seen in Chapter 6 that the surplus production models did not represent adequately the population dynamics of all taxa. Ten taxa exhibited either an insignificant and/or positive relationship between CPUSE and effort and consequently could not be prescribed by a surplus production model. In order to examine the potential net economic yield from the FT fleet it was necessary to make some rather heroic assumptions about the sustainable yield from these 10 taxa.

For the two minor taxa, Rachycentridae and Sharks, which had negative but insignificant relationships between CPUSE and effort, the surplus production fuction given in Table 5, Appendix D and derived from the results given in Table 6.3 were used. Although these functions are not statistically significant, they provide a convenient starting point. Since these taxa are of minor importance both in terms of catch and revenue (i.e. less than 1%), the impact of this assumption on the steady-state economic yield calculation is minor.

The sustainable catch of the eight remaining unmodelled taxa were assumed to follow two alternative functional forms. The first set of potential yield calculation were made under the assumption that the CPUSE of each of these taxa remained constant at the 1978/79 level throughout the simulated period. This was labelled "Case 1". Case 2 considered the more pessimistic proposition that the 1978/79 level of CPUSE and effort of the taxa represent that associated with MSY (maximum sustainable yield). The Schaeffer-Gulland model was employed in Case 2. The parameters of the model were easily established given the MSY and (associated) CPUSE and effort, and an estimate of the catchability coefficient (q). Since the simulated estimates of CPUSE and catch were essentially independent of any value of q, q was set at 0.01 for each of the eight taxa (see Table 8.1 for parameter values). In each case, the best fit surplus production model for each of the remaining 20 taxa given in Chapter 6 and Table 5, Appendix D was used. The initial stock size for each taxon was set to yield the actual CPUSE rate obtained in the 1978/79 period.

8.2.4 Fishing Power and Nominal Effort

The fishing power and rate of nominal effort for each trawler vessel gear class were set at the rate given in Chapter 5. The fishing power estimates used are given in Table 5.18. The fishing power for vessel gear type Class 352 (fish trawlers using high opening net) were set at the 1978/79 level. The fishing power for PKT vessels and Class B and C, SPT vessels were estimated with the same adjustment factors and proxy vessel-gear types described in Section 5.6. The nominal effort for all trawl vessel gear classes was set at a constant rate equal to the average annual nominal effort over the 1975/79 period derived from Tables 7.9 and 7.10. As before, the nominal effort for the Class B SPT vessels was assumed to be equal to that of Class B PKT vessels.

8.2.5 Costs and Prices

The calculation and underlying assumption of the base case cost components were outlined in Chapter 7. Table 8.2 presents a summary of the component costs as well as a brief description of the estimation procedures. Prices, ex-vessel and market levels were set at the mean 1975/79 levels in the calculation of potential yield, except where otherwise stated.

TABLE 8.1 : CASE 2 [1]: SURPLUS PRODUCTION MODELS

	r	k	q	Pop.
Prawns	12.78E-06	17162	0.01	8581
Gerridae	71.26E-06	3410	0.01	2438
Nemipteridae	22.45E-06	9922	0.01	4961
Engraulidae	56.31E-05	202	0.01	101
Loligoidea	54.10E-07	23396	0.01	13673
Carangidae	30.96E-06	5546.2	0.01	4525
Trichuridae	11.26E-06	7524	0.01	3762
Scomberomoridae	46.55E-06	2564	0.01	1282

[1] Estimated on the assumption that CPUSE during 1978/79 was the maximum sustainable CPUSE. The Schaeffer model was used for each taxon.

TABLE 8.2 : COST COMPONENTS OF CLASS E FISH TRAWLERS (1969 RINGGIT)

¶1. Trip Costs [1]	¶ $123.45 per day ¶
¶	¶ ¶
¶2. Labour Costs	¶ ¶
¶a) wage [2]	¶ $71.70 per day ¶
¶b) share	¶i) 50% of net trip receipt ¶
¶	¶ii) 12.5% of vessel's lay for captain's commission ¶
¶	¶iii) $350 per month for engineer's wage ¶
¶	¶iv) $1834 per day non-lay payments ¶
¶	¶v) $17.81 [3] per day in <u>makan laut</u> payments plus trash fish bonus ¶
¶	¶ ¶
¶3. Annual Vessel Costs	¶ $10220.39 ¶
¶	¶ ¶
¶4. Annual Vessel Invest.	¶ $15196.65 ¶
¶	¶ ¶
¶5. Annual Market. Costs	¶ $6365.62 ¶
¶	¶ ¶
¶6. Annual Market. Invest.	¶ $10564.80 ¶

[1] Trip costs plus trash fish payments minus local transport charges.
[2] Per day at sea for entire crew and includes all income sources except <u>makan laut</u>, food payments and extra crew payments.
[3] <u>Makan laut</u> receipts are not treated as a cost to the vessel owner because they are deducted prior to landing. Similarly, trash fish commission is deducted from trash fish revenue prior to its inclusion in <u>Panggu</u> and will therefore not be treated as a cost to vessel owners' share.

8.2.6 Steady-State Economic Yield

In order to obtain a steady-state or equilibrium value of net economic yield, the simulation model was set to run for thirty simulated years for each alternative FT fleet size. Since the annual rate of change in gross harvest weight and net return per vessel was reduced to near zero (less than 1/2% change) by the thirtieth year, the net economic value in that year was taken to represent steady-state conditions.

In Chapter 4 it was argued that the correct economic criterion for managing a fishery is the net present value of the steady-state net economic rent. The maximization of periodic economic yield, recommended in the static framework, was seen to be valid only if the social rate of discount is zero. It was also shown that in the context of an autonomous linear model with perfectly malleable capital and labour, the "optimal" adjustment path to the "optimal" stationary fleet size is the so called "bang-bang" approach. Under the "bang-bang" adjustment policy, the optimization process is to simply choose a stationary fleet size which maximises the net discounted value of the fleet. As already asserted the "bang-bang" approach is unlikely to be optimal in the real world context for there are often significant political and economic costs associated with the adjustment processes. Notwithstanding this, the simulation model does not provide a means of investigating the optimality of various adjustment programs. Furthermore, more research into the adjustment process, particularly with regards to labour, should be undertaken prior to the choice of an adjustment program. The potential yield were thus considered only for a range of stationary FT fleets.

The net present value (NPV) of alternative FT fleets over an infinite time period can be written :

$$NPV = \sum_{t}^{30} NV_t (1/1+\delta)^{t-1} + \frac{NV_{30}}{\delta} (1/1+\delta)^{30} \qquad 8.1$$

where NV_t represents the annual net value produced in year t. Since a steady-state net economic value is assumed to be reached in year 30, the net present value calculations are composed of the contributions over the first 30 years plus present value of the annuity repeated after year 30.

8.3 Results of Simulation Experiments

8.3.1 Basic Experiments

The NPV and net vessel profit (NVP) earned by the entire fleet at each stationary size, assuming an 11% rate of discount are reported in Figures 8.1 to 8.4. To facilitate the interpretation of these results the optimum NPV, fleet size and associated NVP, based upon three alternative discount rates are given in Table 8 3. Figure 8.1 shows the results of experiment 1 using Case 1 production functions and P_1 prawn effort. Figure 8.2 shows the results of experiment 2 that assumes Case 1 production functions and P_2effort. Figure 8.3 and Figure 8.4 show the results of experiments 3 and 4 respectively, where the Case 2 set of production function is used with P_1 and P_2 prawn trawl effort respectively.

The Case 1 set of surplus production functions as shown in Figures 8.1 and 8.2 (which assumes a social discount rate of 11%) yield a maximum NPV of between \$20,847,000 and \$18,321,000 in 1969

TABLE 8.3 : THE STATIC OPTIMUM FLEET SIZE AND NET ECONOMIC VALUE, AND THE DYNAMIC OPTIMUM FLEET SIZE AND PRESENT VALUE OF NET ECONOMIC YIELD PER SIMULATION RUN WITH A RANGE OF DISCOUNT RATES.
(IN 1000'S 1969 RINGGIT)

					Discount Rate					
					6%		9%		11%	
	Case	P	Net Val.	No. Vess.	NPV	No.Ves.	NPV	No.Ves.	NPV	NO.Ves
Experiment 1	1	1	2438	85	33462	89	24771	91	20847	93
Experiment 2	1	2	1693	81	28160	88	21424	89	18321	91
Experiment 3	2	1	2953	80	39784	83	29347	84	24637	85
Experiment 4	2	2	1496	61	29564	75	22818	76	19658	78

FIGURE 8.1: EXPERIMENT NO.1 - ASSUMING A DISCOUNT RATE OF 11% (1969 RINGGIT)

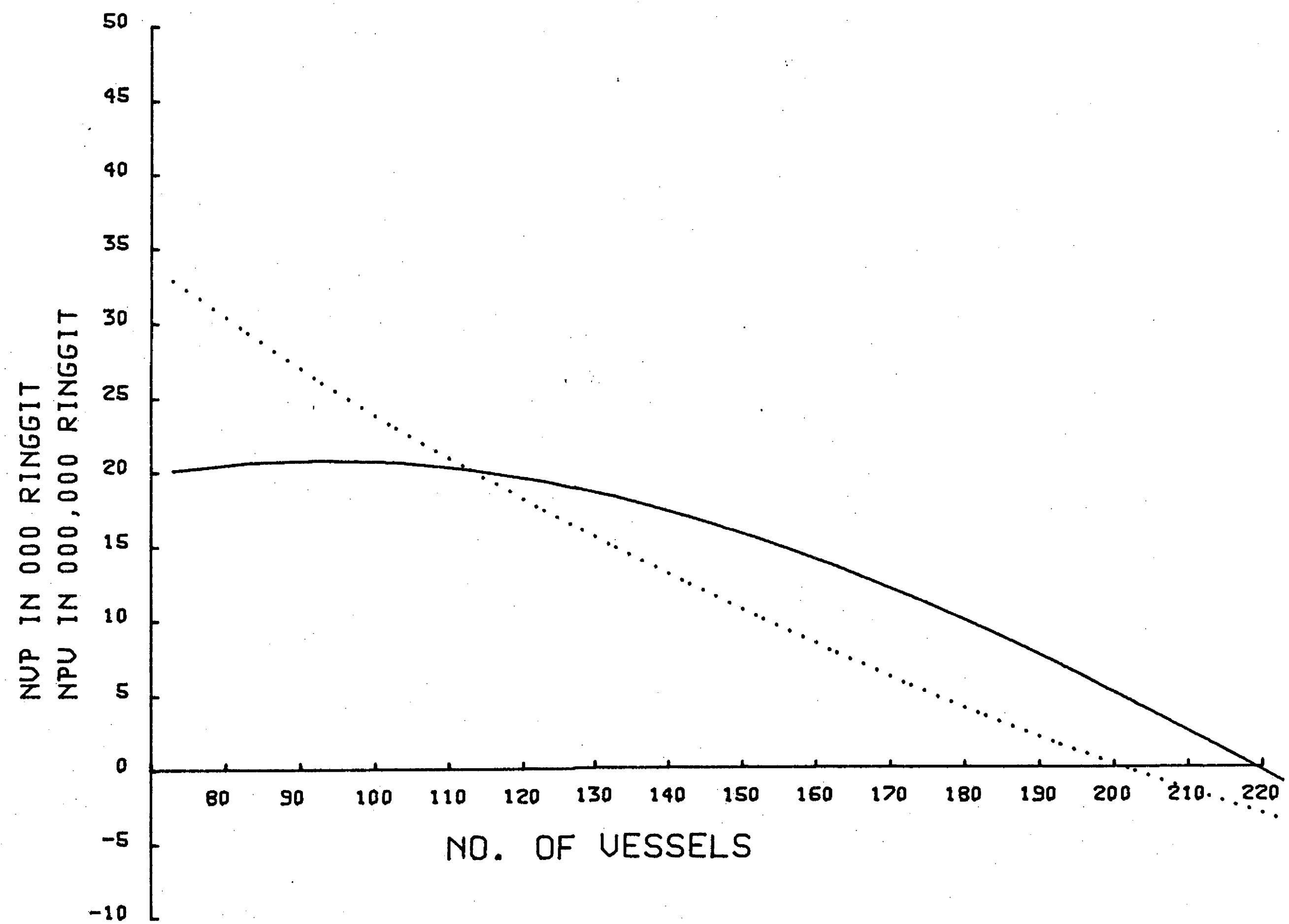


FIGURE 8.2: EXPERIMENT NO.2 - ASSUMING DISCOUNT RATE OF 11% (1969 RINGGIT)

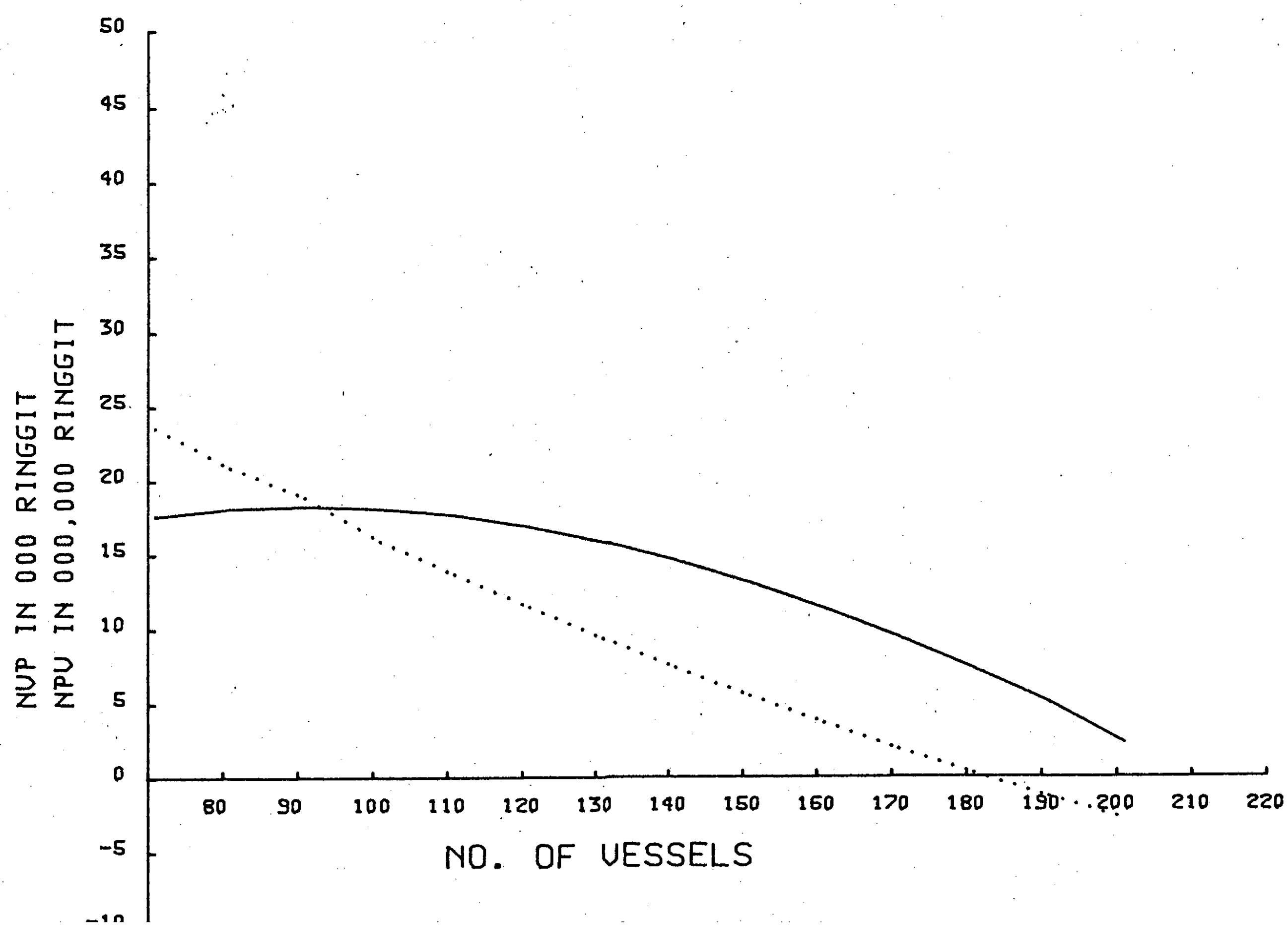
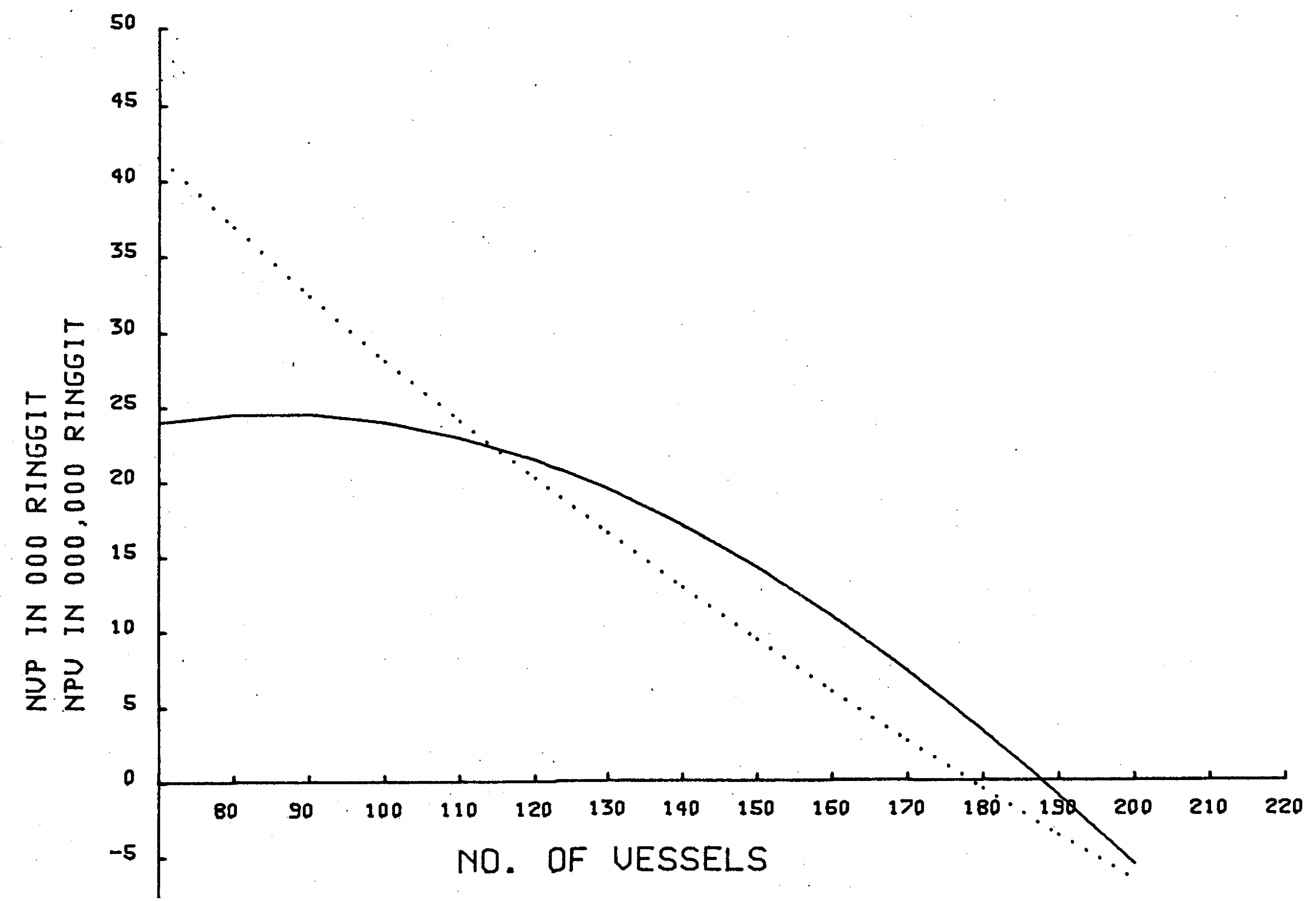


FIGURE 8.3: EXPERIMENT NO.3 - ASSUMING A DISCOUNT RATE OF 11% (1969 RINGGIT)



Ringgit. The optimal fleet under these assumptions would be between 91 and 93 vessels. The Case 2 set of surplus production functions, experiments 3 and 4, exhibits a pattern similar to Case 1 but yields a smaller optimal fleet and larger NPV. The optimal fleet size under such assumptions (Figures 8.3 and 8.4) is between 78 and 85 vessels yielding a NPV of $19,658,000 to $24,637,000.

Experiments 1 and 2 (Case 1 production functions) indicate that the FT fleet will, on the abovementioned assumption of technological change, reach an open access equilibrium between 182 and 201 vessels (Figures 8.1 and 8.2). Under the Case 2 set of production functions, open access will yield a stationary fleet of 178 to 130 vessels (Figures 8.3 and 8.4).

It is instructive to examine the effect of alternative social discount rates on the potential yield calculations (see Table 8.3). As expected from the dynamic model of a fishery discussed in Chapter 4, the optimal fleet size varies directly and the NPV varies indirectly with the social rate of discount. Furthermore, the optimal fleet (δ = 0) is substantially smaller than if it was derived from a positive discount rate. In any case, over the complete range of experiments and social discount rates in Table 8.3, the optimal fleet size varied between 61 and 93 vessels yielding between $18,321,000 and $39,784,000 in 1969 Ringgit.

A continuous expansion of the prawn fleets assumed in P_2 results, as anticipated, in a lower optimal open access steady-state FT fleet size. The decline in the optimal fleet size is not large at about 2 vessels in Case 1, and 8 vessels in Case 2 (Table 8.3). The impact on the open access fleet size is, however, quite significant. In Case 1, if the prawn trawl fleet double in 15 years (assuming P_2)

the open access fleet will be reduced by 19 vessels. In Case 2, the open access fleet will be reduced by 48 vessels (Figures 8.3 and 8.4). An increase in the prawn fleets in Case 2 has a greater relative impact than in Case 1 because of the assumed lower sustainable yield from effort in excess of the 1978/1979 levels for the eight unmodelled taxa.

The calculations of potential rent have thus far assumed constant ex-vessel and market prices and costs. Although an accurate quantitative prediction of future fish prices or costs is lacking, it would appear from past experience that both will probably increase in the near future. It is therefore instructive to examine the effect of a real increase in prices and in cost on the optimal fleet and its NPV. The results of experiment 1 with four alternative growth rates in market and ex-vessel prices and three alternative growth rates in diesel costs assuming a discount rate of 11% are given in Table 8.4. The effect of a 1.5% annual growth rate in all ex-vessel and market prices, equivalent to a total increase of 57% in thirty years, is to increase the optimal fleet from 93 to 110 vessels and to increase its NPV by about $10 million. For each 0.5% across the board increase in taxa prices, the optimal fleet increases by about 6 vessels. A 0.5% annual growth rate in the diesel cost has the expected effect of decreasing both the optimal vessel size by 2 vessels and the NPV by slightly less than $1 million.

8.3.2 Distribution of Rent

It is interesting to examine the economic pay-off that the vessel owners and crew would receive if the FT fleet were restricted to optimal steady-state size. In Table 8.5, the monthly incomes to the

TABLE 8.4 : EFFECTS OF INCREASED TAXA [1] AND DIESEL PRICE ON THE DYNAMIC OPTIMUM FLEET SIZE AND N.P.V. OF NET ECONOMIC YIELD. EXPERIMENT 1 WITH 11% DISCOUNT RATE

Annually Compounded Rate of Increase in 1975/79 Prices	Tot. Increase in Prices	(1000's 1969 Ringgit) No.Ves.	NPV
0%	0%	93	20847
0.5%	16%	99	23772
1%	35%	104	27038
1.5%	57%	110	30686
Annually Compounded Rate of Increase in Diesel Price			
-0.5%	-16%	89	19968
-1%	-35%	87	19066
-1.5%	-57%	85	18125

[1] Ex-vessel and market prices for all taxa were increased at the same rate.

TABLE 8.5 : MONTHLY CREW INCOME AND FT VESSEL OWNER EARNINGS AT OPTIMUM DYNAMIC FLEET SIZE WITHOUT LICENCE FEES [1] (1969 RINGGIT)

	Exp.1	Exp.2	Exp.3	Exp.4	1979
1. Net Vessel Income	-34.95	-247.50	187.95	-261.06	-359.75
2. Net Marketing Income	917.69	763.69	1124.69	760.69	659.40
3. Total Net Income	882.74	516.19	1312.64	499.63	299.65
4. Rate of Return [2]	41%	24%	61%	23%	14%
5. Crew Income					
a. ordinary crew	350.28	315.58	386.67	313.36	241.62
b. engineer or netman	456.77	404.72	511.36	401.40	343.86
c. captain	749.62	649.85	854.24	643.49	440.24

[1] Assuming constant prices at 1975/79 level with 5 crew members and 7 shares
[2] Total invested capital ($25761.45)

vessel owner and crew member are given for experiments 1 to 4 assuming a discount rate of 11% and no licence fee. Vessel owners and crew will earn substantially higher incomes when their monthly incomes are compared with those of the Class E FT crews in 1979. This is particularly so as the calculations are based on fish trawl effort only. Since the returns to capital and labour in the FT fleet are greater than or equal to the opportunity costs, the crew and vessel owners will reap very high incomes in an optimal but untaxed fleet. It is for this reason that FT fleets should only be managed at an optimal fleet size, if a large share of the economic yield could be acquired by the managing authority through taxation or a licence fee.

8.3.3 Biological Extinction

As discussed in Chapter 4, unselective fishing effort on a tropical fishing ecosystem is likely to lead to the eventual extinction of the more k-selective species. Extinction of some species may well be optimum in the sense of maximizing the net economic yield of the fishery. However, open access conditions in such fisheries are likely to result in non-optimal extinction of some species. The cost of open access could indeed be great.

Table 8.6 illustrates the steady-state CPUSE per taxon from each of the four experiments assuming an 11% discount rate. With an optimal FT fleet, a number of taxa will be exploited to or very close to extinction (with a CPUSE of less than 0.1). With the prawn trawl fleet frozen at 1978/1979 levels (as in experiments 1 and 3), two minor demersal taxa, Rays and Serranidae, will be destroyed with an optimal fleet size. If the prawn trawl fleet is allowed to grow as it has in the past, (as represented in experiments 2 and 4) five more demersal

TABLE 8.6 : STEADY-STATE CPUSE PER TAXON FOR EACH EXPERIMENT [1]

		Experiment 1		Experiment 2		Experiment 3		Experiment 4	
		Optimal	Open Access	Optimal	Open Access	Optimal	Open Access	Optimal	Open Access
I. Demersal									
A. Zoobenthic Prey									
Prawns	3	85.81	85.81	85.81	85.81	83.92	83.23	1.08	1.02
B. Large Zoobenthic Feeders									
Rays	17	0	0	0	0	0	0	0	0
C. Brachyura	15	4.82	3.85	0.45	0.37	4.98	4.11	0.46	0.41
D. Prey Fishes									
1(a) Gerridae	6	24.38	24.38	24.38	24.38	21.63	16.65	13.4	16.62
(b) Nemipteridae	7	49.61	49.61	49.61	49.61	60.49	49.68	30.05	24.00
2. Flatfishes	11	15.54	15.09	3.82	3.73	15.73	15.34	3.84	3.78
3(a) Mullidae	26	3.87	0.02	0.03	0	4.61	0.12	0.07	0
(b) Leiognathidae	27	0.03	0	0	0	0.16	0.01	0	0
E. Intermediate Predators									
1(a) Scianidae	8	2.12	0	0	0	5.33	0	0	0
(b) Bramidae	19	3.75	0.5	0.07	0	4.10	1.18	0.13	0.01
(c) Ariidae	22	3.52	0.31	1.33	0.17	4.27	0.53	1.78	0.55
(d) Pomadasyidae	24	2.09	0.85	1.35	0.63	2.27	1.04	1.51	0.98
(e) Lutjanidae	25	0.86	0.38	0.17	0.08	0.94	0.46	0.18	0.12
2. Sepioidea	4	8.99	0.66	0	0	10.26	1.83	0	0
3(a) Sphyraenidae	14	15.69	10.41	12.18	8.62	16.31	11.46	12.80	10.50
(b) Sharks	21	3.79	0.47	0.68	0	4.07	1.13	0.97	0.14
(c) Drepanidae	29	0.33	0	0.17	0	0.38	0.01	0.23	0.04
F. Large Predators									
1. Serranidae	20	0	0	0	0	0	0	0	0
2. Muraenesoadae	23	0.49	0.24	0.01	0.01	0.53	0.28	0.01	0.01
II. Semi-Pelagic									
G. Prey									
1(a) Kembong	1	350.27	210.06	346.55	225.25	363.83	234.25	368.55	288.12
(b) Clupeidae	5	101.73	34.10	92.65	36.10	106.87	48.56	100.79	68.25
2(a) Dorosomidae	18	19.13	7.24	11.82	5.21	20.66	8.95	13.28	8.32
(b) Engraulidae	28	1.01	1.01	1.01	1.01	1.52	1.13	1.40	1.18
H. Intermediate Predators									
1. Loligoidea	2	136.73	136.73	136.73	136.73	157.07	116.70	116.37	93.81
2. Carangidae	10	45.25	42.25	45.25	45.25	40.54	27.10	38.70	31.18
I. Large Predators									
1(a) Chirocentridae	13	5.6	3.7	2.73	1.88	5.76	4.14	2.86	2.35
(b) Rachycentridae	30	0.8	0.03	0.52	0.02	0.87	0.11	0.63	0.22
2(a) Trichiuridae	12	37.62	37.62	37.62	37.62	55.40	42.39	47.72	40.5
(b) Scomberomoridae	16	12.82	12.82	12.82	12.82	18.85	13.81	16.85	14.03
III. Misc. Catch	9	24.29	11.36	0	0	25.95	14.82	0	0
IV. Pooled spp.	31	957.94	689.5	864.76	675.30	1037.30	699.02	773.66	606.14

[1] Assuming an 11% social discount rate.

taxa will be extinguished. These are Leiognathidae, Muraenesoadae, Scianidae, Sepioidea and Miscellaneous catch. It is important to note that the latter three are among the most prolific demersal taxa caught by the combined trawl fleet. Their demise would represent a substantial reduction in the biomass of the demersal community unless, of course, the more r-selective taxa e.g. Nemipteridae, Gerridae and Prawns do not continue to grow in a compensatory manner.

Under open access, four other taxa will be harvested to the point of extinction. The Mullidae and Drepanidae taxa would, judging from the results in Table 8.6, be nearly destroyed under open access even if prawn trawl effort is frozen (experiments 1 and 3). However, if the prawn trawl fleet expands as they have in the past, Bramidae and Sharks will also be extinguished. It must also be recognised that the biomass of many of the remaining demersal taxa will be severely reduced under open access especially if prawn trawl effort increases. The significance of this is that fish populations are known to collapse when exploited beyond a given minimum population size [Clark, 1976, pp.311-317]. The viability of the remaining demersal populations thus may well be jeopardised under open access. In experiments 2 and 4, 12 demersal taxa representing over 60% of all demersal taxa, were found to be exploited at or close to the point of extinction.

8.4 Reduction of FT Fleet

The potential yield calculations show clearly that the FT fleet is severely over-capitalised. The high rate of return earned by the FT fleet in the 1978/79 period cannot be sustained. The rapid growth in fishing power and fishing efficiency brought about by the introduction of the high opening net and more powerful propulsion systems prevented the fleet and its exploited taxa from reaching a steady-state. The speed with which the technology was introduced and adopted obviously allowed the FT fleet to reap substantial short term rent. The process was, however, simply mining or consuming the exploited stocks in excess of their regenerative capabilities. As a result the fleet has expanded beyond even its open access steady-state size. In 1978/79, the FT fleets comprised 234 vessels which is greater than the open access fleet size of 170 - 201 as estimated in the four experiments. More importantly, the fleet must be reduced by between 53% and 68% (i.e. 124 - 159 vessels) in order to achieve maximum economic efficiency. Such a reduction necessarily requires a significant period of time. However, the first step is to gain control of fishing effort through its main determinants.

No conclusive prognosis concerning the state of the prawn fleets in relation to their optimal or open access size can be made. Even though the fleets did not display rapid technological change during the 1965/79 period, the size of the fleet grew steadily. The rapid and continuous growth, in particular of the SPT fleet, since 1976 would suggest that the prawn trawl fleets were not in a bionomic equilibrium during 1978/1979. However, the growth in fishing effort took place via an increase in the number of vessels rather than through the introduction of more efficient vessels. This pattern of growth is less likely to yield short term supra normal rents when the fleet has expanded beyond its open access size. Nonetheless, the supra normal rent earned by the prawn fleet in 1978/1979 may not be sustainable and the fleet may have expanded beyond their open access size. However, the extent of over-capitalisation in the prawn fleets is unlikely to be as great, in a relative sense, as in the FT fleet. This is particularly so given the importance of and the indeterminate effect of fishing effort on the prawn taxon.

The most reasonable strategy, especially given the high likelihood that the prawn fleets have expanded beyond their optimal (in terms of economic efficiency) size, is to freeze the fishing effort of the fleets at their 1978/79 levels. This can be easily done by banning the issue of new licences. As for the FT fleet, even though it is imperative that more research be conducted particularly into the dynamics of the exploited populations, our results strongly indicate that the total fishing effort of the FT fleet should be substantially reduced. In the interim, however, the existing licensing program should be adjusted to control more efficiently and, in the case of the FT fleet, to reduce fishing effort.

It was seen in Chapter 2 that there already exists a basic legal framework for the control of the Malaysian trawl fishery. A mandatory vessel and gear licensing program has been enforced for a number of years. Furthermore, the general policy of restricting the number of trawl gear licences has been maintained at least since 1972. The findings of this study, however, suggest that the licence scheme should be improved in a number of ways to control more effectively fishing effort.

In Chapter 4 it was asserted that particularly in fisheries where restrictive measures are necessary, licences should authorise the use of some basic set of vessel characteristics and/or gear types. Ideally, the authorised dimensions of a fishing unit should be the key determinant of fishing power. Restricting these dimensions will therefore control fishing effort more accurately than simply restricting the number of vessels. In Malaysia, the gear licence issued does not restrict any of the major vessel characteristics or gear types. The licence merely permits a specified vessel to use a trawl net. The licence cannot be legally transferred to another party, but can be transferred to a replacement craft subject to the permission of the Fisheries Division. The trawl gear licence therefore does not provide an accurate means of controlling fishing effort. A licence owner can change the fishing power of the vessel by simply changing its engine, gearbox, hull and/or trawl type.

In Chapter 5 the key determinants of fishing power were found to be the horsepower of the engine and the net type. Both these inputs are easily identifiable. However, enforcing restrictions on trawl types may prove to be difficult. Judging from these it would seem appropriate that the conditions of the trawl gear licence in Malaysia should be changed to restrict the horsepower class of the operating vessel and the type of trawl net, i.e. either prawn or fish net. However, it does not appear feasible to differentiate between the type of prawn trawler (i.e. SPT or PKT) as was done in this study. This distinction is insufficiently precise and permanent for licensing purposes. A further complication will be the multi-gear characteristic of the FT fleet. The flexibility of the FT fleet, with regard to choice of trawl type, needs to be preserved especially given the high degree of risk and uncertainty in the fishery. One means of maintaining flexibility would be to allow the fish trawl licence holders the right to use a prawn net since fish trawlers are unlikely to switch to predominant use of the prawn trawl if a rationalization program is successfully implemented.

It was acknowledged in Chapter 4 that in the long run restrictions on one or two factors of production are not likely to succeed in containing the expansion of fishing capacity. This is due to the flexibility of fishing technology. The incentive to circumvent any such restriction will be enhanced if a limited entry regime is successful. The extent to which the gains from controlling the horsepower and trawl type will be dissipated by expanding the use of other dimensions of effort, naturally depends on the substitutability of other inputs.

In Chapter 5, no rigorous attempt was made to examine the substitutability of inputs. However, it was noted that the primary means of increasing fishing power, especially for the high opening net, was to enhance the speed and power of the vessel and the size dimension of the net. Scope, therefore exists for the vessel owners to increase the fishing power of their vessels without changing their engine size or trawl type. For example, the plan and rigging of the net may be changed; fish detection equipment may be adopted and the traction power of the vessel increased through the use of a more powerful gearbox and better propellers. Admittedly, it is unrealistic to regulate all that vessel owners may do to improve the performance of their vessels. In any event, it is known from evidence available that the key variables in trawler performance are engine horsepower and trawl type, and these are readily measurable.

Existing gear licences therefore should specifically authorise the use of given engine classes only and of given trawl types. Apart from licence reforms and irrespective of their form, the regulatory agency should initiate a program of continuous monitoring in order to assess the impact of controls on the fleet's capacity and technology, and to determine the need for supplementary measures.

Prawn trawlers which make up the majority of trawlers operating in Peninsular Malaysia exhibit no tendency of increased fishing power. The smaller vessel classes dominate the prawn fleets in all states. Furthermore, it appears from the case study of Perlis/Kedah, prawn trawl owners have little incentive to switch to a larger vessel class. As there is no discernible relationship for prawn trawlers between rate of return and vessel class, vessel owners would seem to have little incentive to subvert licence restrictions on engine horsepower. The same cannot be said for the FT fleets. As seen in Kedah/Perlis, despite the freeze on FT vessel numbers since 1974, the fishing capacity of the fleet had more than doubled by 1979, mainly through the shift to more powerful engine classes. It is thus obvious that the incentive for the FT fleet to circumvent restrictions on horsepower will remain, especially if a rationalization program is implemented, and constant monitoring will be necessary.

The Kedah/Perlis trawl fishery is conducted by independent private entrepreneurs whose primary motivation is to increase or safe-guard their earnings. In this context, regulations that create incentives for fishermen to comply with regulations for their own self interests are preferrable to those based solely on compulsion. It would thus be beneficial to take advantage of the normal market processes whenever possible in the regulatory process.

It follows that to allow licences to be transferable and divisible would lead to the development of a private market for licences. The establishment of a licence market would provide an opportunity for the vessel owners to replace, improve and adjust the scale of their vessels within the aggregate limit of the fleet capacity specified by the regulatory agency. The opportunity to trade their rights will give the owners a degree of flexibility which would facilitate more efficient adjustment to changing conditions and which would also blunt incentives to contravene controls. Similarly beneficial is the means, provided by an active licence market, by which the regulating authority can adjust fleet capacity through sales and purchase without causing involuntary dislocations. In the case of the Kedah/Perlis FT fleet, transferability of licence together with restrictions on horsepower would allow (probably without too much resistance) the Fisheries Division to purchase the licenses of all Class C and some Class D vessels. This measure would eliminate these vessels from the fishery and thus decrease the capacity of the fleet directly. It would also prevent these vessels from switching to Class D or Class E. Given the low rate of return earned by these Class C and some of the Class D vessels, the cost to the agency of purchasing them need not be high. A market for licences could also be used to monitor the rent generating capacity of the fleet and would be of invaluable help in the task of deciding on taxes and licence fees.

As mentioned in Chapter 4, the government does not need a licence market to eliminate vessels from the fishery. It can proceed in a manner similar to the compulsory acquisition of land for specified purposes at market rate. However, a licence market would provide an economically efficient means of excluding some vessels from the fishery without the element of compulsion.

The main argument against the transferability of licences is the fear that it will undermine the ability to regulate the distribution of rent [Pearse, 1980]. Vessel owners would, the argument goes, sell their licences to their subsequent regret (a major concern in the Alaskan Fisheries,[Adasiak, 1979]) and the potential for the monopolisation of licences, especially by the processors, is also undesirable.

The need to protect licence owners from their own decisions is unlikely to be compelling in Malaysia where the objective is to protect and/or enhance Malay interest especially since most of the trawl owners are Chinese. The prevention of monopoly of licences is the more serious objection. The vertically integrated structure of the FT firms present the potential for increasing returns to scale. Freely transferable FT licences may well, if left unchecked, become concentrated in the hands of a few wealthy market agents. The problem is less serious in the prawn trawl fleet where owner-operated vessels dominate. Nonetheless, monopolisation may be checked by stipulating the maximum number of licences that a single business may possess.

There are three convincing reasons for licence fees much higher than that charged in 1979. First, although the trawl fleets, in Kedah/Perlis at least, earn substantial profits, a higher licence fee would capture some of the resource rent and so doing reduce the incentive for the fleet to expand its capacity through technological changes. Second, a licence fee in an over-capitalised fishery would help to drive the marginal vessels from the fishery and in turn reduce capacity. Finally, revenue from licence fees could be used to defray administrative and enforcement costs and to assist a buy-back program. The licence fee should ideally be progressive over horsepower class and time inorder that more of the rent may be captured. As a guide, Table 7.12 suggests that it should exceed $100 per annum. A complete schedule of licence fees can only be drawn up after due political deliberation.

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